HAUTE AUTORITÉ DE SANTÉ

TECHNOLOGICAL ASSESSMENT REPORT

# Organisation of the early management of acute ischaemic stroke using mechanical thrombectomy

**July 2018**

This technological assessment report, prepared with a view to mandatory National Health Insurance cover, can be downloaded from
www.has-sante.fr

**Haute Autorité de santé**
Communication - Information Department
5, avenue du Stade de France – F 93218 Saint-Denis La Plaine Cedex
Tel.: +33 (0)1 55 93 70 00 – Fax: +33 (0)1 55 93 74 00

This document was approved by the College of the French National Authority for Health in July 2018.

# Table of contents

Abbreviations and acronyms ..... 5

**1. Context ..... 9**
1.1 Information source ..... 9
1.2 Current general organisational principle of French neurovascular services ..... 9
1.2.1 Current organisation of early stroke management ..... 10
1.2.2 Regulatory context ..... 11

**2. Assessment endpoints ..... 15**

**3. Assessment method ..... 16**
3.1 Documentary search ..... 16
3.1.1 Automated bibliographic databases ..... 16
3.1.2 Websites ..... 16
3.1.3 Other sources ..... 16
3.2 Selection of identified documents ..... 17
3.2.1 Selection of documents analysed in this report ..... 17
3.2.2 Methodological analysis of the literature ..... 17
3.2.3 Description of the documents selected ..... 17
3.3 Consultation of stakeholders ..... 23
3.3.1 Collection of information from healthcare professionals via the "Mechanical thrombectomy in the management of cerebral infarction patients" Steering Committee (COPIL DGOS) ..... 23
3.3.2 Regional health board surveys ..... 23
3.3.3 Collection of information from the patients concerned ..... 23
3.4 Consultation of intracranial revascularisation device manufacturers ..... 23
3.5 Stakeholder review *via* COPIL DGOS ..... 23

**4. Assessment of MT practice requirements ..... 25**
4.1 Data from the literature ..... 25
4.1.1 Therapeutic window ..... 25
4.1.2 Technical platform ..... 27
4.1.3 Diagnostic neurological imaging capabilities ..... 27
4.1.4 INR unit organisation ..... 28
4.1.5 Requirements for prescription and use issued by intracranial revascularisation medical device manufacturers ..... 33
4.2 COPIL position on MT practice requirements ..... 33

**5. Assessment of team composition and training of professionals involved in care ..... 36**
5.1 Data from the literature ..... 36
5.1.1 Mechanical thrombectomy stakeholders ..... 36
5.1.2 Medical practitioner training and qualifications in MT ..... 38
5.1.3 Regional certified CME process initiative: example of Nouvelle-Aquitaine region ..... 46
5.2 COPIL position on clinical and technical skills ..... 47

**6. Assessment of the care pathway of the MT candidate patient ..... 50**
6.1 Data from the literature and French practice ..... 50
6.1.1 MT candidate patient pathway ..... 50
6.1.2 Detection: information and awareness ..... 53
6.1.3 Prehospital phase ..... 56
6.1.4 Telestroke in the MT candidate patient care pathway ..... 60
6.1.5 Regional feedback on telemedicine in France: data collected from regional health boards ..... 61
6.1.6 Hospital phase: organisation of patient admission ..... 66
6.1.7 Proposed algorithm for the early management of stroke patients (update of the algorithm from the 2009 HAS guidelines) ..... 67
6.1.8 Foreseeable impact on the organisation of care according to intracranial revascularisation device manufacturers ..... 70

6.1.9 Patient-centred care ....70
6.2 COPIL position on the care pathway of the MT candidate patient .... 71

**7. Overview of care provision in France .... 75**
7.1 Interregional Schemes of Healthcare Organisation .... 75
7.2 ARS survey: current regional organisation of early management of stroke .... 76
7.2.1 Current regional care provision network ....77
7.2.2 Regional specificities and difficulties accessing MT ....86
7.2.3 Challenges in respect of optimal roll-out ....91
7.3 Establishment of resources enabling access to emergency care in less than 30 minutes .... 97
7.4 SFNR survey: overview of INR units in France .... 97
7.4.1 Materials and methods ....97
7.4.2 Survey findings ....97
7.5 COPIL position on care provision in France .... 98

**8. Strategic guidelines .... 102**
8.1 Supplement INR activity with MT units .... 102
8.1.1 Team optimisation ....102
8.1.2 INR unit optimisation ....102
8.1.3 Optimisation of imaging-based patient selection ....102
8.1.4 MT pathway optimisation ....104
8.2 MT activity assessment and follow-up .... 106
8.2.1 Registry participation ....106
8.2.2 Peer review process ....107
8.2.3 Indicators of quality and safety of care ....107
8.2.4 Participation in stroke research ....111

**9. Assessment findings .... 114**
9.1 PRACTICE REQUIREMENTS .... 114
9.1.1 Therapeutic decision ....114
9.1.2 Diagnostic neuroradiology unit ....114
9.1.3 MT unit ....115
9.1.4 Link between practice of MT and stroke centre ....115
9.2.1 MT team composition ....115
9.2.2 MT interventionalist skills ....116
9.2.3 Initial training ....116
9.2.4 Continuous training ....116
9.2.5 Minimum activity threshold for MT interventionalists ....117
9.2.6 Minimum activity threshold for MT units ....117
9.3.1 MT candidate patient pathway ....117
9.3.2 Detection: information and awareness ....117
9.3.3 In the prehospital phase ....118
9.3.4 Telestroke in the care pathway ....119
9.3.5 In the hospital phase ....119
9.4 OVERVIEW OF CARE PROVISION IN FRANCE .... 120
9.4.1 Interregional Schemes of Healthcare Organisation ....120
9.4.2 Regional organisation of neurovascular services ....120
9.4.3 Issue of accessibility of care provision and structure of services ....120
9.4.4 Issue of out-of-hours services ....121
9.4.5 Issue of compliance with standards, quality and safety of care ....121
9.4.6 Issue of cooperation and development of information systems ....121
9.4.7 Issue of better valuation of INR activity, including MT ....121
9.5.1 Supplement INR activity with MT units ....121
9.5.2 MT activity assessment and follow-up ....123

References ....125

Fact sheet .... 129

## Abbreviations and acronyms

**AHA** ..... *American Heart Association*

**DOAC** ..... Direct oral anticoagulants

**ARS** ..... *Agence régionale de santé* (Regional Health Board)

**IECB** ..... Improvement of expected clinical benefit

**ASA** ..... *American Stroke Association*

**CVA** ..... Cerebrovascular accident (stroke)

**IS**..... Ischaemic stroke

**cf**..... *confer*

**CT** ..... *Computed Tomography*

**CTA**..... *Computed Tomography Angiography*

**CCT**..... *Certificate of Completion of Training*

**CNAMTS**..... *Caisse nationale d'assurance maladie des travailleurs salariés* (National health insurance fund for salaried workers)

**DGOS** ..... *Direction générale de l'offre de soins* (Directorate General of Health Care Provision)

**RCT**..... Randomised controlled trial

**ESNR**..... *European Society of Neuroradiology*

**ESMINT** ..... *European Society of Minimally Invasive Neurological Therapy*

**UEMS**..... *European Union of Medical Specialists*

**fig**..... figure

**SCDT** ..... Specialised cross-disciplinary training

**g**..... gram

**Gy** ..... gray

**HAS** ..... *Haute Autorité de santé* (French National Authority for Health)

**Hz**..... hertz

**MRI** ..... Magnetic resonance imaging

**IV**..... intravenous

**JO** ..... *Journal officiel de la République française*

**LPS** ..... List of procedures and services

**MARS** ..... Medical anaesthetist and resuscitation specialist

**mmHg**..... millimetres of mercury

**INR**..... Interventional neuroradiology

**LVO**..... Large vessel occlusion

**WHO** ..... World Health Organization

**HC**..... Healthcare

**PDSES**..... *Permanence des soins en établissements de santé* (Healthcare institution out-of-hours service)

**PTS**..... *Pacte territoire santé* (Regional healthcare agreement)

**rt-PA** ..... Recombinant tissue plasminogen activator

**ECB** ..... Expected clinical benefit

**EMS** ..... Emergency medical services

**ED** ..... Emergency department

**SFN** ..... *Société française de neurologie* (French neurology society)

**SFNR** ..... *Société française de neuroradiologie* (French neuroradiology society)

**SFNV** ..... *Société française de neurovasculaire* (French neurovascular society)

**SFR** ..... *Société française de radiologie* (French radiology society)

**SIOS** ..... *Schéma interrégional d'organisation sanitaire* (Interregional Scheme of Healthcare Organisation)

**SMUR** ..... *Service mobile d'urgence et de réanimation* (Emergency mobile resuscitation unit)

**IVT** ..... Intravenous thrombolysis

**MT** ..... Mechanical thrombectomy

**TLM** ..... Telemedicine

**IRT** ..... Interventional radiology therapy

**SC** ..... Stroke centre

**NICU** ..... Neurointensive care unit

# Introduction

Ischaemic stroke (IS) is an acute condition which, according to the World Health Organization (WHO), represents the second leading cause of mortality worldwide, and the third cause of mortality in developed countries (1).

It requires extremely urgent care, which represents a major public health challenge. Until 2015, the treatment of IS was based on timely recanalisation of the occluded artery by intravenous (IV) thrombolysis. The arrival of mechanical thrombectomy (MT) has made it possible to expand the therapeutic arsenal for IS, and modify its management.

Two requests relating to mechanical thrombectomy (MT) have been submitted to the French National Authority for Health (HAS). The first was a joint request from three learned societies (Société française de neuroradiologie (SFNR), Société française de radiologie (SFR), Société française de neurovasculaire (SFNV)) and the CNAMTS medical procedure department. The second request was made by the Directorate General of Health Care Provision (DGOS).

The purpose of the joint request made by the learned societies and CNAMTS was to assess the MT procedure for the treatment of acute IS with a view to the inclusion of this new technology on the list of procedures and services (LPS) reimbursable by social security. The request from DGOS relates more specifically to the organisational aspect associated with the introduction of this technique into conventional practice.

Based on the initial analysis of these assessment requests, HAS proposed the sequential production of two assessment reports in order to:

- in a first part, assess the efficacy and safety of MT in the indication in question so as to determine an expected clinical benefit (ECB) and an improvement of expected clinical benefit (IECB) rating, thereby enabling the inclusion of the procedure in the LPS, if applicable;
- in a second part, assess the organisational aspect of MT in terms of practice and healthcare organisation requirements associated with the roll-out of MT in the event of such inclusion being approved.

The first part was covered within the scope of the "Endovascular intracranial artery thrombectomy" assessment report published by HAS in November 2016 (2). MT was awarded an IECB rating of II (high), leading to the inclusion of the procedure "*Intracranial artery thrombus evacuation by the transcutaneous arterial route*" (EAJF341) by National Health Insurance in 2017.

DGOS stated in its request that "*the management of victims of stroke will involve new facilities and new stakeholders in the stroke services, neuroradiologists and interventional neuroradiologists. The current demographic framework is based on the existence of around forty neuroradiology units in France with one to four qualified neuroradiologists per unit to carry out this procedure, which needs to be carried out within one hour of thrombolysis*".

As such, DGOS requested HAS to specify the practice and environmental requirements for MT in terms of:

- composition and coordination of teams involved in care;
- technical platform;
- organisational requirements for the optimal implementation of MT.

Therefore, this report corresponds to the second part of the assessment of MT with a view to characterising the organisational aspects of MT, as per the request from DGOS.

In parallel with its request, DGOS has set up an "Endovascular mechanical thrombectomy for the treatment of stroke" Steering Committee aimed at defining the suitable regulatory framework for the appropriate organisation of MT provision for cases of cerebral infarction, based on the organisational assessment conducted by HAS. Moreover, the Steering Committee also has the role of identifying the changes expected by the stakeholders involved.

# HAS recommendations

In view of the assessment presently being conducted, HAS has issued the following recommendations:

**R1 → Expand the pool of physicians with MT expertise in order to meet future care needs by extending MT training (initial SCDT and continuous training) to other radiologists and to other medical specialities (neurologists, neurosurgeons and, if the need is not sufficiently covered, to interventional cardiologists).**

**R2 → Increase the human and material resources of the 39 stroke centres in order to provide MT under optimum conditions.**

In particular, it will be necessary to ensure that the stroke centre is provided with:

- a sufficient number of neurologists;
- a diagnostic imaging unit;
- at least four qualified MT interventionalists (the regional health boards may organise pooled out-of-hours services).

**R3 → Create complementary care provision by setting up new MT units within healthcare institutions already including primary stroke centres.**

Unlike an INR unit, these MT units will not carry out all interventional neuroradiology procedures, but will focus on MT procedures.

These MT units should particularly be provided with:

- at least three qualified interventionalists with MT expertise, to cover the needs arising from practice requirements and out-of-hours services (the regional health boards may organise pooled out-of-hour services);
- the technical platform required to conduct MT defined above;
- neurosurgical care available 24/7 on-site or in agreement with another institution approved for this activity.

The exact determination of the number and location of these MT units affiliated with primary stroke centres will be carried out by the regional health boards based on specific criteria (travel times to comprehensive stroke centre, population pool size, comprehensive stroke centre capacity, out-of-hours services, etc.).

**R4 → Define a minimum activity threshold in respect of MT procedures annually and per unit. Failing literature of a sufficient level of evidence, HAS, on the opinion of experts, proposes an initial annual threshold of 60 cases. This threshold level should be assessed during the scheme ramp-up phase and after five years, in the light of the number and distribution of cases.**

Moreover, this minimum activity threshold may also be modulated by the Ministry of Health or regional health boards based on specific scenarios (opening of a new unit, ramp-up of activity). Smoothing of the activity over a number of years (e.g. three years) may be envisaged. Specific MT follow-up indicators will also be put in place, in order to enable the follow-up of the suitability of MT procedures in particular.

**R5 → Promote and repeat information campaigns aimed at the general public. The information should not be restricted to subjects with vascular risk factors, but should target the population as a whole, including young people.**

# 1. Context

## 1.1 Information source

This context section has been drafted based on a non-systematic literature review including reviews, epidemiological studies, course materials, and best clinical practice guidelines.

## 1.2 Current general organisational principle of French neurovascular services

Ischaemic stroke (IS) is a major healthcare issue due to its frequency and the ensuing risk of disability. As such, each year, approximately 130,000 people suffer from a stroke in France: 40,000 die as a result and 30,000 retain severe after-effects. Furthermore, the number of strokes is increasing by 5% each year in France. Therefore, stroke management is a public health priority. One of the major challenges in this management is revascularisation therapy during the acute IS phase and controlling vital signs liable to change the prognosis, reduce mortality and the risk of disability. For a number of years, acute stroke management has been based on admission to a specialised stroke centre (*UNV*) and the option to conduct timely recanalisation of the occluded artery (therapeutic window of 4 hours 30) by intravenous injection of recombinant tissue plasminogen activator (rt-PA).

In 2015, the organisation of the management of emergency cases of cerebral infarction due to proximal cerebral artery occlusion changed with the publication of six multicentre randomised controlled trials. These studies on MT demonstrated its efficacy in terms of favourable neurological outcome for patients with acute IS associated with large vessel occlusion (LVO) (3-7). In 2016, the French multicentre study, THRACE, conducted under real-life conditions, confirmed the benefit of this procedure conducted in addition to intravenous thrombolysis; moreover, this study contributed to the roll-out of mechanical thrombectomy on a national scale (8).

These findings led HAS in 2016 to consider that MT offers a benefit in the management of patients with acute IS, associated with LVO visible on imaging within six hours after the onset of symptoms, either from the outset in combination with intravenous (IV) thrombolysis, or as a second-line procedure after IV thrombolysis treatment failure, or on its own in the event of contraindication to IV thrombolysis (2).

The introduction of this new treatment and the accommodation of patients in neurointensive care units (NICU) are a major organisational challenge. The major challenge for public authorities is now that of providing an optimal organisation of care so that the majority of eligible patients[1] for this procedure are able to benefit as quickly as possible after the onset of symptoms. Therefore, management must be provided within the framework of organised and coordinated services. These services currently include a prehospital phase which is vital during the acute phase (identification of symptoms, triggering of alert and patient dispatch), and a hospital phase for emergency diagnosis and treatment set-up. Moreover, in order to achieve the best possible clinical outcomes with endovascular stroke therapy, structured training of the medical practitioners providing this specialised care is required. MT is an interventional neuroradiology (INR) procedure which consists of retrieving a clot from an intracranial artery using specific medical devices commonly referred to as "*stent retrievers*" or thromboaspiration systems. This procedure is currently carried out in approved INR units within the framework of interregional schemes of healthcare organisation (SIOS) in accordance with the decrees pertaining to the roll-out and practice requirements (9, 10), and performed by practitioners with expertise in accordance with the order of 15 March 2010 (11). The *European Stroke Organisation* (ESO), and Société française de neuroradiologie (SFNR) and So-

[1] According to the requesting party, the target population is estimated at between 3000 and 7000 patients per year on French territory.

ciété française neurovasculaire (SFNV) have drawn up codes of practice and guidelines for the practice and organisation of this activity (12, 13).

### 1.2.1 Current organisation of early stroke management

Historically, stroke cases were treated in hospital internal medicine or neurology departments. However, particularly since the arrival of rt-PA IV thrombolysis enabling recanalisation of the occluded artery with a therapeutic window of 4 hours 30 after the onset of symptoms, it has become necessary to be able to act extremely quickly, round-the-clock, with a high degree of technical skill.

In order to meet this need, "stroke centres" (UNV) emerged, selected by the public authorities as the most suitable care model for stroke management.

Indeed, according to the 2002 ANAES guidelines, structured stroke management in stroke centres provides a demonstrated benefit for the "death and dependency" and "death and institutionalisation" composite endpoints. It is reported that this benefit was observed prior to evidence of the efficacy of specific therapies, such as thrombolysis (14).

The organisation of early stroke management then evolved due to a number of studies, conducted within the framework of the HAS best practice guidelines in 2009 (15), the 2010-2014 National stroke plan (16), and multiple regulatory texts.

In 2009, HAS published, in its best practice guidelines, an algorithm for the management of patients with suspected stroke, which includes the following stages: detection, prehospital phase, initial hospital phase, and thromoblysis indications (15).

More specifically, these guidelines were particularly aimed at:

- optimising prehospital and intrahospital services for patients with suspected stroke, in order to be able to offer superior care to the largest number of patients possible;
- reducing the interval between the onset of symptoms and the first specialised care;
- reducing the frequency and severity of functional sequelae associated with stroke through early multidisciplinary management, set up as quickly as possible in a stroke centre, or failing this in an institution having set up care services in coordination with a stroke centre.

The 2010-2014 National stroke action plan (16) envisaged changes to the organisation of the management of victims of stroke implemented particularly with the roll-out of stroke centres, functionally identified units, recognised by the regional health boards, including dedicated neurointensive care beds and "conventional" hospital beds.

As such, in 2017, the local network set up by the public authorities and SFNV consists of approximately 139 stroke centres, regardless of type, throughout the territory, and which operate mostly as part of a network and in conjunction with a university hospital-based reference stroke centre where they are close to one another. The conditions for opening stroke centres are framed by circular No. DHOS/O4/2007/108 of 22 March 2007 (17).

In France, a distinction is made between two levels of stroke centre:

- ***UNV de territoire*** **(primary stroke centres)** (equivalent to "*Stroke Units"* in Europe and "*Primary Stroke Centers*" in the United States), in which the multidisciplinary team, including vascular neurologists, nurses, nurse's aides, physiotherapists, speech therapists, occupational therapists, psychologists and social workers, is trained on specific, concerted IS management;
- ***UNV de recours*** **(comprehensive stroke centres)** ("*Stroke Centres"* in Europe and "*Comprehensive Stroke Centers"* in the United States), which, in addition to their role as a hub stroke centre for a locality or region, have 24-hour access to technical INR, neurosurgery, neuroanaesthesia and vascular surgery platforms.

Finally, telemedicine, applied to thrombolysis, helps complete the local network by enabling emergency departments at a distance from primary or comprehensive stroke centres to accommodate cerebral infarction patients. These departments are run within a network with a stroke centre or reference neurologist, the staff are trained on stroke detection and management (common

healthcare protocols, multidisciplinary review meetings), and are generally affiliated with a medical department. This is described as a local stroke centre (18).

As such, for a number of years, IS management has been based on the emergency medical services followed by admission to a stroke centre, and, more recently, on the involvement of INR units if thrombectomy is deemed to be indicated (thus, 39 institutions (7%) had an INR platform in 2017 (19)). Use of telemedicine may be necessary in the absence of a diagnostic neuroradiology unit at the initial hospitalisation facility.

Based on the findings of the 2017 collection of 2016 data, indicators falling under "Initial stroke management" published by HAS in December 2017 (19), the weighted data in respect of institution activity volume demonstrate that:

- 72.6% of patients are reported to receive care in an institution including a stroke centre;
- 60.7% of patients are reported to receive care in a stroke centre;
- 6.19% of patients are reported to receive care via telemedicine (telestroke).

### 1.2.2 Regulatory context

In addition to the HAS best practice guidelines, the organisation of the early management of stroke and, more specifically of the facilities involved in this management, is governed by a very comprehensive regulatory framework.

#### ► Emergency medical services

- Duties and organisation of units involved in the Emergency medical services (S.A.M.U).
  - Article R.6311-1 of the French Public Health Code:

The role of emergency medical services is to respond using exclusively medical resources to emergency situations.

Where an emergency situation requires the combined use of medical resources and rescue resources, the emergency medical services combine their resources with those used by the fire and rescue services pursuant to article 16 of the law of 22 July 1987 cited above.

  - Article R.6311-2 of the French Public Health Code:

Under article R.6311-1, EMS carry out the following duties:

1) provide a 24-hour medical helpline;
2) determine and activate, within the shortest possible time-frame, the response best suited to the nature of the calls;
3) ensure the availability of appropriate public or private hospitalisation resources for the patient's condition, while also respecting free choice, and prepare admission;
4) organise, if applicable, transport to a public or private institution using a public medical transport service or private medical transport contractor;
5) attend to the patient's admission.

  - Articles R.6311-6 and R.6311-8 of the French Public Health Code:

Call taking and handling centres (SAMU-Centre 15) enable, particularly via their assigned telephone advice line (15), immediate 24-hour access by the population to emergency care and the participation of private medical practitioners in the emergency medical assistance framework.

Their participation, like that of other stakeholders, in the emergency medical assistance framework is determined by agreement

### ► Stroke centres

A number of texts govern the framework of early stroke management and the role of stroke centres.

- DHOS/DGS/DGAS circular No. 517 of 3 November 2003 pertaining to stroke management (20):
  - describes the patient pathway from the first signs of stroke, his/her arrival in the emergency department, up to the return home;
  - emphasises the role of the "Centre 15" advice line in the prehospital phase, given the importance of expeditious management of stroke which is a medical emergency;
  - envisages structuring hospitalisation, in the acute phase, through the set-up of stroke centres, eliciting functional rehabilitation as quickly as possible, and providing medico-social care in concert with the general practitioner.
- DHOS circular of 22 March 2007 pertaining to the role of stroke centres in the care of patients presenting with stroke (17):
  - the stroke centre is the key hub in the regional services defined within the framework of the regional scheme of healthcare organisation (SROS), of comprehensive care for stroke patients from the acute phase. It makes it possible to combine, particularly within the framework of intensive care, all of the medical and paramedical expertise required for early implementation of treatment and of the rehabilitation programme specific to each patient.
- Circular of 6 March 2012 pertaining to the organisation of regional stroke patient care services (21):
  - the organisation of services is mentioned as a major area in the 2011-2014 National stroke plan which is intended to be rolled out and implemented by each regional health board in line with its strategic regional healthcare plan. The endpoints for optimal pathway organisation are handling of all stroke patients by SAMU-Centre 15, direct stroke centre access, priority MRI access;
  - patients with suspected stroke must benefit from 24/7 priority access to brain imaging insofar as possible (MRI as the first-line choice, or failing that, CT scan). Preference should be given to the most expeditious imaging technique. Institutions hosting a stroke centre must, if possible, be equipped with emergency department-specific MRI resources, open on a 24-hour basis. Institutions not hosting a stroke centre, but receiving large numbers of emergency cases, must organise, in conjunction with the regional health board, access to a diagnostic imaging platform with out-of-hours radiology services either on-site, or via telemedicine.

### ► Interventional neuroradiology units

A number of texts govern the framework of interventional activities in the context of endovascular neuroradiological imaging, with the decrees of 19 March 2007 which set out the set-up requirements (No. 2007-366) and technical terms of practice (No. 2007-367).

- Decree No. 2007-366 of 19 March 2007 relating to the set-up requirements applicable to endovascular interventional neuroradiological activities and amending the public health code (regulatory provisions):
  - article R.6123-104: the endovascular interventional neuroradiological activities mentioned in para. 13 of article R.6122-25 pertain to the cervicocephalic and spinal cord region;
  - article R.6123-105: the approval envisaged by article L.6122-1 may only be awarded to a healthcare institution or a healthcare cooperative group if it has on the same site, optionally through an agreement with another institution based on this site, in a common building or, failing that, adjacent buildings, the following resources:
    - a hospitalisation unit providing care for patients in the context of endovascular interventional neuroradiology activities,
    - a specific international digital subtraction angiography suite for these activities,
    - an approved neurosurgery unit,
    - an approved intensive care unit,
    - a technical imaging platform for performing neuroradiological examinations (9).

- Decree No. 2007-367 of 19 March 2007 pertaining to the technical terms of practice applicable to interventional endovascular neuroradiology activities:
  - article D.6124-148: patients are hospitalised in the context of endovascular interventional neuroradiology activities either in a dedicated unit for interventional neuroradiology activities, or in a neurosurgery unit, or in a neurology unit, or, failing that, in a medical or surgery unit;
  - article D.6124-149: the medical staff required for endovascular interventional neuroradiology activities include:
    - at least two medical practitioners with proven experience and training in endovascular interventional neuroradiology procedures, certified as per the terms specified by the order of the Ministry of Health,
    - anaesthetist and resuscitation specialists based on a protocol agreed with the medical practitioners cited above,
    - and if required, a qualified medical practitioner specialised in physical medicine and rehabilitation;
  - article D.6124-150: the out-of-hours services mentioned in article R.6123-108 and continuity of care are provided on each site by a medical practitioner meeting the requirements mentioned in para. 1 of article D.6124-149 and an anaesthetist and resuscitation specialist. These parties shall carry out their duties on-site or as part of an on-call system or, if applicable, by agreement with other healthcare institutions or healthcare cooperative groups. In the latter two cases, the time to arrival must be compatible with safety requirements;
  - article D.6124-151: the practice of endovascular interventional neuroradiology activities requires access at all times, optionally by agreement with another institution, to:
    - magnetic resonance imaging and CT scan examinations,
    - continuous intracranial pressure measurement and recording equipment,
    - a transcranial Doppler ultrasound apparatus,
    - bacteriological, haematological, biochemical tests, as well as those relating to haemostasis and blood gases conducted extemporaneously,
    - labile blood products;
  - article D.6124-152: the practice of endovascular interventional neuroradiology activities requires access at all times to at least:
    - an interventional digital subtraction angiography suite meeting the same anaesthesia and asepsis requirements as those of an operating theatre,
    - a control suite with radioprotection equipment in compliance with the regulations in force,
    - a digital subtraction angiography apparatus enabling three-dimensional image reconstruction (10).
- Order of 19 March 2007 defining the minimum activity of institutions carrying out endovascular interventional neuroradiology activities:
  - article 1: the minimum annual activity in respect of endovascular interventional neuroradiology activities mentioned in article R.6123-110 of the public health code is set, per site, at 80 procedures in the cervicocephalic and spinal cord region (22).
- Order of 15 March 2010 defining the requirements for proof of training and experience in endovascular interventional neuroradiology procedures:
  - the medical staff envisaged in article D.6124-149 (para. 1) must provide proof of qualification as a radiodiagnostic and medical imaging specialist or, failing that, qualification as a neurosurgery or neurology specialist, and of training and experience in endovascular interventional neuroradiology procedures meeting the following requirements:
    - holder of a university or interuniversity qualification in diagnostic and therapeutic neuroradiology, including two years of theoretical training,
    - continuous practical training for at least three years including one year in diagnostic radiology and two years in interventional neuroradiology in an institution carrying out more than 80 endovascular interventional neuroradiology procedures annually (11).

### ► Telemedicine: telestroke

Telemedicine is a scheme defined and framed by article 78 of the HPST law No. 2009-8979 (23) and decree No. 2010-1229 (24) of 19 October 2010. It is considered as a means for improving the performance of the healthcare system of sufficient importance to make the regional telemedicine programme one of the constituent parts of the Regional healthcare programme. Telemedicine in conjunction with the organisation of Out-of-hours services and Stroke management are two of the five priority objectives of the national telemedicine programme (25).

Based on the decree of 19 October 2010, circular DGOS/R4/R3/PF3/2012/106 of 6 March 2012 pertaining to the organisation of regional stroke patient care processes (21, 23, 24, 26) defines telestroke as:

- *" … remote neurological consultation: includes via appropriate means the sharing of all data useful for the care of a stroke patient. It enables, via video-conferencing systems, direct discussion with the patient (medical history and clinical examination) who is in the local institution assisted by a medical or non-medical healthcare professional and exchange of all data suitable for being forwarded and shared (pathology, imaging data, electronic record). As such, it involves the joint examination of the patient by a medical practitioner or a healthcare professional responsible for the patient in the local institution (requesting practitioner) and the neurovascular medical practitioner in the reference institutions (requested vascular neurologist), ...";*
- *" … remote radiological consultation: enables the medical practitioner in contact with the patient to obtain the opinion and interpretation of a radiologist or neuroradiologist located at a distance from the site at which the imaging examination was conducted (requested radiologist)…";*
- *"… remote assessment: neurovascular pathology specialist opinion provided outside the actual participation of the patient in the telemedicine procedure… ";*
- *"… "telestroke" remote medical assistance and remote monitoring: this involves, for the medical practitioner in charge of a stroke patient, assisting with certain procedures and patient follow-up. It may involve, for the requested neurologist, checking that thrombolysis has been carried out properly, for the radiologist, assisting with the imaging exam...".*

The Directorate General of Health Care Provision has issued a document on "Telemedicine and legal liabilities involved" (26).

# 2. Assessment endpoints

The endpoint of this assessment report is to analyse the changes caused by the introduction of MT in the strategy for the early management of stroke, and describe the arrangement of an organisational system including:

- the practice and environmental requirements in respect of endovascular intracranial artery thrombectomy in the treatment of acute ischaemic stroke;
- referral of patients with suspected stroke to treatment facilities;
- multidisciplinary coordination.

# 3. Assessment method

The assessment method used by HAS in this report and defined in the framing phase is based on:

- a systematic literature review used to complete the defined assessment fields;
- a medico-scientific analysis of the selected literature data;
- consultation of the institutions and healthcare professional bodies concerned, as stakeholders;
- a survey of patient associations.

The findings of the assessment report are based on the data compiled and collected. These findings are subsequently reviewed by the National Committee for the Evaluation of Medical Devices and Health Technologies and ultimately approved by the HAS College.

## 3.1 Documentary search

### 3.1.1 Automated bibliographic databases

#### ► List of databases queried

- *Medline* (*National Library of Medicine*, United States);
- *Embase* (*Elsevier*);
- *The Cochrane Library* (*Wiley Interscience*, United States);
- BDSP Public health database;
- *Science Direct* (*Elsevier*);
- *National Guideline Clearinghouse* (*Agency for Healthcare Research and Quality*, United States);
- *HTA Database* (*International Network of Agencies for Health Technology Assessment*).

#### ► Database query strategy and results

The database query strategy is presented in Table 1 of Appendix 1. It specifies for each question and/or study type the search terms used, the Boolean operators, and the search period.

The search terms were either thesaurus terms (MESH descriptors for *Medline*), or terms from the title or the abstract (free-text terms). They were combined in the number of steps required using the Boolean operators "AND", "OR" and "EXCEPT". The search included publications in English and French, published between October 2010 and October 2017.

This query was submitted in October 2017. Documentary monitoring was conducted until April 2018.

### 3.1.2 Websites

This search included systematic reviews, meta-analyses, health technology assessment reports or best practice guidelines published by various organisations (education board, learned society, Ministry of Health, etc.).

#### ► List of sites consulted

The list of sites consulted is presented in Appendix 1. This search was submitted in October 2017. Documentary monitoring was conducted until April 2018.

### 3.1.3 Other sources

Organisational reports of interregional schemes of healthcare organisation (SIOS) were also consulted in October 2017. Moreover, HAS studies on key performance indicators in stroke were also analysed in January 2018. Finally, the members of the "Endovascular mechanical thrombectomy for the treatment of stroke" Steering Committee also cited publications during the review period.

## 3.2 Selection of identified documents

### 3.2.1 Selection of documents analysed in this report

Following the systematic bibliographic search (bibliographic databases and websites), an initial selection, based on the literature selection criteria, resulted in the inclusion of around 110 articles. After reading the titles and abstracts, 57 articles were selected for *in extenso* review:

- five technological assessment agency reports;
- ten systematic reviews with or without meta-analysis;
- ten non-randomised comparative clinical studies;
- ten observational studies;
- fifteen best practice guidelines;
- seven narrative reviews.

A second selection phase conducted on *in extenso* articles resulted in the inclusion of 32 documents analysed and cited in the report. Two reports on key performance indicators and two randomised controlled trials identified by bibliographic monitoring and healthcare professionals were also selected.

### 3.2.2 Methodological analysis of the literature

In total, 36 documents were selected to respond to the questions within the scope of the assessment. The documents selected are as follows:

- six healthcare organisation and planning (SIOS) reports in France;
- one TJC (*The Joint Commission*) report from the healthcare organisation and programme accreditation and certification body in the United States;
- one systematic review with meta-analysis;
- three systematic reviews without meta-analysis;
- two randomised controlled trials (RCTs);
- thirteen best practice guidelines;
- two reports on key performance indicators;
- four observational studies (one cohort study and three retrospective studies);
- four narrative reviews.

The literature selected was the subject of a methodological quality analysis using international grids: the AGREE II grid (*cf.* Appendix 2) for best practice guidelines, the AMSTAR grid for systematic reviews and meta-analyses (*cf.* Appendix 3), the INAHTA grid (*cf.* Appendix 4) for technological assessment reports.

Some documents, particularly the narrative and general reviews reporting expert opinions, due to their nature, did not lend themselves to a critical analysis based on the methodological criteria conventionally used by HAS for selecting articles and determining their level of scientific quality. Hence, the recommendations and guidelines compiled merely have a descriptive value herein.

### 3.2.3 Description of the documents selected

The documents selected for the assessment of the organisational aspect of MT in IS management are described below, the findings of these studies are reported in the sections dedicated to each area assessed.

#### ► Technological assessment agency publications (*Health technology assessment*, HTA) and healthcare organisation and planning reports

##### TJC (*The Joint Commission*) report published in September 2017

This report relates to the general description of the new Stroke Centre certification process in the United States.

### Healthcare organisation and planning reports from interregional schemes of healthcare organisation (SIOS)

The endpoint of these tools is to set up a healthcare organisation suitable for highly specialised activities while retaining good accessibility by the population to care provision in the fields in question. SIOS definition studies are organised by practitioner correspondents in the regions in question, a steering committee assists with this coordination, including regional health board representatives, medical and administrative professionals.

## ► Randomised controlled trials

### DAWN trial by Nogueira *et al*. (2018) (27)

DAWN is an open-label multicentre randomised controlled trial comparing MT to medical treatment alone for cases of acute ischaemic stroke (AIS) having a carotid or sylvian proximal occlusion in the M1 portion with an indeterminate time of onset of less than 24 hours or determined time of onset of 6 to 24 hours with clinical imaging mismatch (difference between severity of clinical deficiency and infarction volume). The latter is defined based on age, NIHSS score and the lesion volume obtained by CT perfusion scanning or MRI imaging (RAPID software). Patients were randomised to receive either thrombectomy plus conventional treatment (MT group), or conventional treatment only (control group). The primary endpoints are the mean disability score on the modified Rankin scale (ranging from 0 [death] to 10 [no symptoms or disability]) and the functional independence measure (score of 0, 1 or 2 on the modified Rankin scale, which ranges from 0 to 6, with higher scores indicating more severe disability) at 90 days.

### DEFUSE 3 trial by Albers *et al.* (2018) (28)

DEFUSE 3 is an open-label, blinded, multicentre randomised controlled trial (38 centres in the United States) comparing MT to medical treatment alone for cases of carotid AIS at 6 to 16 hours from the onset of symptoms or normal neurological examination with proximal occlusion of the M1 segment of the MCA and/or carotid artery and radiological criteria assessed based on CT perfusion scanning or MRI imaging using RAPID software (particularly including an AIS volume ≤ 70 cc, penumbra in infusion ≥ 15 ml on a *T Max*[2] > 6 sec). The primary endpoint is the mean disability score on the modified Rankin scale (range of 0 to 6, the highest scores indicating more severe disability) at 90 days.

## ► Systematic literature reviews and meta-analysis

Four systematic literature reviews were identified, including one with a meta-analysis.

### Systematic review by Daubail *et al.* (2016)

The authors analysed the clinical findings, as well as the organisational aspects of the latest endovascular trials and recent meta-analyses including almost 15% of patients treated with rt-PTA. The organisational aspects analysed concern the creation of a system including triage of patients with suspected stroke in primary stroke centres and their transport to comprehensive stroke centres as quickly as possible (29).

### Systematic review and meta-analysis by Ryu *et al.* (2016)

The endpoint of this study was to assess the scientific evidence available in respect of the utility of perfusion imaging in determining the eligibility for treatment of stroke patients and in predicting clinical outcomes (30).

[2] *Time to maximum of the residue function*.

### Systematic review by Smith *et al.* (2015)

The clinical neuroscience department, Hotchkiss Brain Institute of the University of Calgary, stroke department (Canada), and the neurology department, Massachusetts General Hospital, Boston (United States) published a review aimed at discussing the implications of the new endovascular therapy era on the organisation of stroke care systems in North America (31). The authors suggest six principles to guide the adaptation of these systems and provide preliminary guidelines for the change. These principles which are based on the criteria proposed by the *Institute of Medicine* in its report "*Crossing the Quality Chasm*" relating to quality of care: effective, patient-centred, timely, equitable, safe, and efficient.

### Systematic review by Evans *et al.* (2017)

The Stroke Research Centre, Department of Brain Repair and Rehabilitation, University College London Institute of Neurology, and the Institute of Neuroscience and Newcastle University Institute for Ageing in the United Kingdom published a practical guide to mechanical thrombectomy (32). The endpoint of this systematic review was to provide neurologists and other medical stroke specialists with an overview of the probative data available with a description of the practical aspects of treatment provision and future challenges. The purpose of this document is to provide recommendations particularly for certain areas not clearly described in clinical trials (these recommendations are based on the evidence available, or failing that, on expert opinion), and highlight the areas of uncertainty requiring further research.

## ► Best practice guidelines

Fourteen international guidelines and one national recommendation were identified.

### Code of practice of mechanical thrombectomy in France (2016)

Société française de neuroradiologie (SFNR) and Société française neurovasculaire (SFNV) have drawn up a code of practice and guidelines for the practice and organisation of MT activity (12). According to the authors, these guidelines are the French adaptation of the guidelines issued at the consensus conference (Stockholm, 16-18 November 2014) including three learned societies, ESO (*European Stroke Organisation*), ESMINT (*European Society of Minimally Invasive Neurological Therapy*) and ESNR (*European Society of Neuroradiology*). The method used to prepare these guidelines is not described in the document.

### "Standards of practice in interventional neuroradiology" guidelines (2017)

ESNR, ESMINT and the neuroradiology division of UEMS (*European Union Of Medical Specialists*) set up a work group assigned the task of drafting a consensus document on "Standards of practice in interventional neuroradiology" (33). These guidelines are based on expert opinions and on the best evidence available, in relation to the optimal requirements for the safe practice of interventional neuroradiology.

### *American Heart Association* / *American Stroke Association* (AHA/ASA) guidelines (2015) and (2018)

This targeted update of the 2013 guidelines for the early management of patients with acute IS particularly focuses on endovascular therapy. The purpose of these guidelines was to provide an up-to-date set of guidelines[3] for clinicians caring for adult patients with acute IS, prehospital care providers, allied health professionals, and hospital administrators.

The method used to draft the guidelines consisted of setting up a panel of experts, conducting a review of the literature in relation to stroke published since the previous guidelines. The levels of evidence and the recommendation classifications meet the criteria in respect of levels of evidence

[3] These guidelines replace the 2013 guidelines and subsequent updates.

and classification applied by *the American College of Cardiology* / AHA from 2015 (34). All the guidelines were approved unanimously by the members of the work group.

The exhaustive document defines the cutting-edge management of acute stroke. The authors highlight a number of areas involving change for stroke care systems, imaging, eligibility for thrombectomy, post-treatment management, and secondary prevention (35).

### *Royal College of Physicians* guidelines: "*National clinical guideline for stroke*" (2016)

The Royal College of Physicians in London published guidelines on the role of MT in the strategy for the management of IS. This edition included updates of the data published since 2012, with documentary searches completed until September 2015 (36).

The working party:

- sought to separate recommendations that relate to the organisation and provision of stroke services to populations from those that relate to the management of individuals with stroke;
- included specific recommendations for those who commission and plan services for people with stroke.

The method used for drafting the guidelines consisted of using quantitative and qualitative evidence where appropriate. According to the working party, as the full breadth of stroke interventions and care cannot be evaluated in the "gold-standard" of a randomised controlled trial (RCT), it was sought to guide practice using the best available evidence.

### European Recommendations on Organisation of Interventional Care in Acute Stroke (EROICAS) (2016)

The European recommendations on organisation of interventional care in acute stroke were published after the publication of the consensus conference by ESO, ESMINT, ESNR, EROICAS (37). These guidelines were drafted in a collaborative framework by a multidisciplinary group of nine clinical researchers (neurology, neurosurgery, neuroradiology, neurological intensive care and emergency medicine) from seven European countries representing six European learned societies[4].

The work group discussed and ruled by consensus on specific therapeutic questions (15 questions) and selection criteria in the literature. The literature search was restricted to RCTs, systematic reviews and meta-analyses of RCTs. The group subsequently identified all the literature available and selected the eligible studies.

The quality and level of evidence and guidelines (based solely on RCT data) were discussed for each question by the group as a whole, and the guidelines were approved by a majority consensus of the work group. In the manner of the GRADE approach, the quality of the probative data was deemed high, moderate, low and very low.

### Recommendations of the Society of Vascular and Interventional Neurology (SVIN) (2016)

In 2016 in the USA, the Society of Vascular and Interventional Neurology (SVIN) issued guidelines for effective application of endovascular therapy of acute stroke using the "8D" approach in the stroke chain of survival approved by the *American Heart Association / American Stroke Association* (AHA/ASA) from 2013 (38).

Critical components of this effort include:

[4] European Academy of Neurology (EAN), European Association of Neurological Societies(EANS), European Society of Emergency Medicine (EuSEM), European Society of Minimally Invasive Therapy (ESMINT), European Society of Neuroradiology (ESNR), European Stroke Organisation (ESO) were appointed by the participating societies and confirmed by the respective executive boards.

- public health education campaigns regarding stroke symptoms and the availability of highly effective treatment options that are critically time-dependent;
- education of first responders regarding in-field recognition and triage of stroke patients to MT-capable centres in a time-dependent fashion;
- continued evolution of the comprehensive stroke centre (CSC) model to incorporate specific criteria for receiving and treating LVO AIS patients.

### International multi-society consensus (2017)

A number of learned societies[5] issued an international consensus on the definition of suitable training for medical practitioners required to carry out endovascular procedures on acute IS patients (39).

These guidelines are based on previous diagnostic cerebral angiography, carotid stent and acute stroke treatment training, performance standard and accreditation documents written and approved by a number of learned societies[6] in 2010 (40) and 2012 (41).

### Guidelines from the *British Society of Neuroradiologists* (BSNR) "*Training guidance for mechanical thrombectomy*" (2017)

In the United Kingdom, the members of the *UK Neurointerventional Group* (UKNG) and of the *British Society of Neuroradiologists* (BSNR) drafted, under the aegis of the *Royal College of Radiologists* (RCR), guidelines on the training and expertise required to practise mechanical thrombectomy (42). These guidelines propose to create a pathway for practitioners (pre- or post-*Certificate of completion of training*) wishing to obtain RCR-recognised training to perform and participate in an acute stroke service in the UK.

This document draws on previous and current training guidance. It has been produced in response to an anticipated shortfall in service capacity and is intended to supplement, rather than replace current RCR training guidance.

### Guidelines from the Royal College of Physicians and Surgeons of Canada (FRCPC) of the neuroscience department of the University of Montreal (2017)

The Royal College of Physicians and Surgeons of Canada drafted an expert opinion on endovascular therapy. The aim of this recommendation is to define the role of the stroke physician during endovascular therapy of acute IS (43).

### Recommendations of the Department of Health Coverdell Stroke Program and the *American Heart Association / American Stroke Association* (AHA/ASA) (2017)

These recommendations drafted jointly by the Department of Health of the State of New York, the *American Heart Association* (AHA), and the *American Stroke Association* (ASA) are aimed at enhancing systems of care for stroke with large vessel occlusion (44).

The drafting method consisted of invitations (n=157) sent to prehospital, hospital, and Department Health leaders across upstate New York. Attendees participated in a moderated day-long meeting which began with didactic sessions followed by group recommendation generating sessions. Pre-

[5] *American Academy of Neurological Surgeons / Congress of Neurological Surgeons* (AANS/CNS), *American Society of Neuroradiology* (ASNR), *Asian Australasian Federation of Interventional and Therapeutic Neuroradiology* (AAFITN), *Australian and New Zealand Society of Neuroradiology – Conjoint Committee for Recognition of Training in Interventional Neuroradiology* (CCINR) *representing the* RANZCR (ANZSNR), ANZAN *and* NSA, *Canadian Interventional Neuro Group* (CING), *European Society of Neuroradiology* (ESNR), *European Society of Minimally Invasive Neurological Therapy* (ESMINT), *Japanese Society for Neuroendovascular therapy* (JSNET), *Sociedad Ibero Latino Americana de Neuroradiologica* (SILAN), *Society of NeuroInterventional Surgery* (SNIS), *Society of Vascular and Interventional Neurology* (SVIN), *World Federation of Interventional and Therapeutic Neuroradiology* (WFITN).

[6] *Society of NeuroInterventional Surgery* (SNIS), *American Academy of Neurology* (AAN), *American Association of Neurological Surgeons / Cerebrovascular Section* (AANS/CNS), *and Society of Vascular & Interventional Neurology* (SVIN)).

and post-meeting assessments were conducted to assess stroke systems knowledge and gauge participant goals/concerns. Participants provided recommendations in two domains:

- prehospital (EMS tools and operationalising transport);
- interfacility transfer.

Recommendations were than ranked using:

- an impact matrix A: high, B: moderate, C: low;
- and a feasibility of implementation matrix (1: high, 2: moderate, 3: low).

After the meeting, recommendations were thematically analysed, concentrating specifically on A-level recommendations. Six weeks post-meeting, participants, organised into workgroups, were provided the results for review, comment, and subsequent agreement.

### HAS stroke guidelines (2009)

These best practice guidelines concern the early management of stroke: detection, prehospital phase, initial hospital phase, thrombolysis indications (15).

The purpose of these guidelines is to:

- identify points of information for the general public in order to raise awareness of the warning signs and the urgency of getting treatment;
- optimise prehospital and intrahospital services for patients with suspected stroke in order to be able to offer superior care to the largest number of stroke patients possible;
- reduce the frequency and severity of functional sequelae associated with stroke through early multidisciplinary management, set up as quickly as possible in a stroke centre, or failing that in an institution having set up suspected stroke patient management services in coordination with a stroke centre;
- improve the work practices of SAMU-Centre 15 triage physicians, emergency medicine physicians and all professionals involved in the early management of stroke cases (including TIA cases).

## ► HAS reports on key performance indicators (KPIs)

KPIs measure key stages throughout the management process. They are used to measure and guarantee the quality of care according to its three aspects: efficacy and safety of care, access to the best care. They represent shared benchmarks of quality of care, regardless of the organisation model. KPIs apply to practices and processes making a direct contribution to clinical outcomes. As such, complementary to and on the basis of the array of stroke guidelines from learned societies and professional associations, KPIs represent tools for analysing and implementing quality of practice (45, 46).

### Results of indicators in respect of improvement in the quality and safety of care – Initial stroke management, 2017 campaign – 2016 data

This document presents the results of the 2017 collection of 2016 data, in respect of indicators under the topic "Initial stroke management". This data collection was conducted under the coordination of the French National Authority for Health, by all healthcare institution having a medicine, surgery, obstetrics (MCO) activity, and providing care for patients hospitalised for stroke.

The results for these indicators reflect the quality of care in each of the healthcare institutions in question. They are also, on a national level, an observatory of the quality of care in French healthcare institutions (19).

### Telestroke key performance indicators – Emergency management, January 2013 (HAS)

Key performance indicators make it possible, in the context of the roll-out of the telestroke scheme, to measure clinical outcomes, compare them in care services, and measure improvements for the patient enabled by the technology (46).

## 3.3 Consultation of stakeholders

These organisations and patient associations were contacted as stakeholders pursuant to decree No. 2013-413 of 21 May 2013, in this instance as groups concerned in practice by the consequences of this report, i.e. by the prescription of this INR procedure. As such, they were to represent and express the general interest of their members. This consultation was conducted in accordance with the stakeholder consultation procedure put in place by HAS[7].

### 3.3.1 Collection of information from healthcare professionals via the "Mechanical thrombectomy in the management of cerebral infarction patients" Steering Committee (COPIL DGOS)

The "Mechanical thrombectomy in the management of cerebral infarction patients" Steering Committee set up by DGOS is made up of representatives from divisions of the Ministry of Health (DGOS, DSS, DGS), CNAMTS, HAS, the Technical Agency for Information on Hospital Care (ATIH), professional associations (SFR, SFNR, SFNV, SFN, SFMU), Regional Health Boards (ARS), healthcare institutions, and patient representatives (Association France-AVC).

HAS attended three COPIL meetings (18 February 2016, 10 November 2016 and 1 February 2018) and thus was able to discuss directly with the Committee members. Moreover, in this context, the data from the survey conducted by SNFR were presented (data also forwarded to HAS and presented in section 7.3).

### 3.3.2 Regional health board surveys

A questionnaire (*cf.* Appendix 5) was sent via the Secretariat General of social ministries to all seventeen regional health boards 2017, with reminders sent up to October 2017.

While exhaustive responses were not obtained, ten of the thirteen regional health boards in Metropolitan France (76.9%) and four of the four regional health boards in French overseas departments and territories (50%) responded (i.e. an overall response rate of 70.6%). The findings of this survey are presented in section 7.2.

### 3.3.3 Collection of information from the patients concerned

The patient association France-AVC (Association assisting stroke patients and their families) was requested for its position by questionnaire in July 2017. This questionnaire and the *in extenso* response drafted by France-AVC in September 2017 are presented in Appendix 6.

## 3.4 Consultation of intracranial revascularisation device manufacturers

Intracranial revascularisation device manufacturers (Covidien[8] and Stryker Neurovascular) were also requested for their position in relation to MT prescription and practice requirements and on the impact of MT on the organisation of care. This position is reported in sections 4.5 and 6.7 of this report.

## 3.5 Stakeholder review *via* COPIL DGOS

A preliminary version of this report (including the critical literature analysis, the consultations of the stakeholders mentioned in section 3.3, along with a preliminary version of the HAS guidelines) was

[7] HAS stakeholder consultation procedure, June 2014. http://www.has-sante.fr/portail/upload/docs/application/pdf/2014-09/c_2014_0115_adoption_procedure_parties_prenantes.pdf

[8] The manufacturer Covidien has since become "*Metronic Minimally Invasive Therapies*".

submitted to the COPIL for review in March 2018. The accompanying questionnaire for this review phase is presented in Appendix 7. The position expressed by the stakeholders following this review is broken down into the different areas of the assessment.

# 4. Assessment of MT practice requirements

MT practice requirements were in part discussed in the first part of the assessment of endovascular intracranial artery thrombectomy (2). As per SFNV recommendations on the role of MT in the management of acute cerebral infarction with anterior circulation artery occlusion of July 2015 (13) and the SFNR code of practice of MT in France (12), MT must be carried out in an institution equipped with a neurointensive care unit (NICU) authorised under the current SIOS, with a view to carrying out this procedure under optimum conditions for the patients and the neuroradiologist, without reducing the time to MT treatment. Moreover, the choice of anaesthetic procedure is decided for each patient, jointly by the anaesthetist and the interventional neuroradiologist.

A number of publications (mostly Clinical Practice Guidelines) were identified in order to specify the organisation of the technical MT platform, diagnostic neurological imaging capabilities, and INR unit organisation.

## 4.1 Data from the literature

### 4.1.1 Therapeutic window

In the 2016 HAS report (2), as in all of the recommendations and guidelines cited above, MT is indicated in the management of patients with acute IS, associated with LVO visible in imaging within six hours after the onset of symptoms. The decision to carry out MT must not delay IV thrombolysis. Similarly, IV thrombolysis must not delay the commencement of MT. However, there are many cases where it is difficult to accurately determine the time of onset of stroke, as in the case of wake-up stroke or in cases where the patient, frequently elderly, is discovered and not fit to respond to questions. In 2018, two trials (DAWN and DEFUSE 3) were published on carrying out MT after the six-hour interval for certain patient sub-groups. In particular, those with large vessel occlusion and exhibiting a mismatch between the symptoms and lesion size suggest the presence of an injured but not yet infarcted area (penumbral area), but which could be retrieved with arterial recanalisation.

#### ► Trial by Nogueira *et al*. (2018) (27)

The trial entitled DAWN is one of the first studies on delayed MT up to 24 hours after the last time that the patient was seen to be asymptomatic. The 206 patients included in the DAWN trial presented with stroke associated with intracranial carotid or middle cerebral artery occlusion. They were divided into three groups: for those over 80 years, the inclusion criteria included an NIHSS score > 10 and a lesion volume < 21 ml. For those under 80 years, they could be randomised in the case of an NIHSS score > 10 and lesion volume < 31 ml or NIHSS score > 20 if the lesion was large (< 51 ml). In total, 107 patients received thrombectomy treatment, 99 were included in the control group and benefited from a conventional treatment optionally including thrombolysis.

The trial was discontinued at the intermediate analysis stage at 31 months due to the positive outcomes in the MT group.

Both groups were comparable, except for the higher presence of atrial fibrillation and wake-up stroke in the thrombectomy arm, and more IV thrombolysis procedures in the other arm. It should be noted that the vast majority of patients (almost 90%) had presented with wake-up stroke (67% in the thrombectomy arm) or stroke of indeterminate onset, and only ten patients in the thrombectomy arm and fourteen patients in the medical treatment only arm had presented with stroke of known onset of more than six hours. The recanalisation rate was 77% in the thrombectomy arm (*versus* 39% in the control group). The median interval between the time at which the patient had last been seen normal and the post-thrombectomy recanalisation was 13.6 hours.

At 90 days, the patients of the MT group presented with less signs of disability than the controls (Rankin score 5.5 versus 3.4), which is equivalent, in Bayesian analysis, to an adjusted difference of 2.0 points (credible interval, CI 1.1 to 3.0; retrospective superiority probability > 0.999). Further-

more, 49% achieved an at least partial degree of independence, versus 13% in the absence of endovascular therapy (adjusted difference, 33 points as % (absolute value), CI 24 to 44; retrospective superiority probability > 0.999).

The incidence of symptomatic intracranial haemorrhage was not different between the two treatment groups (6% for the MT group versus 3% for the control group; p=0.50). No difference was observed in respect of the risk of death (p=1). In total, treating two patients by thrombectomy makes it possible to improve the disability score for one of these, and treating 2.8 patients makes it possible to improve the functional independence of a stroke patient (NNT).

### ► Trial by Albers *et al.* (2018) (28)

The trial entitled DEFUSE 3 is a trial including 182 patients aged 18-90 years with an NIHSS score ≥ 6, presenting with carotid stroke between 6 and 16 hours after proximal middle cerebral or internal carotid artery occlusion and imaging criteria assessed by CT perfusion imaging or MRI. The MRI results were analysed by the automated software known as RAPID, capable of identifying a mismatch between the lesions observed by Diffusion Weighted Imaging (DWI) and those obtained by Perfusion Weighted Imaging (PWI). The "*target mismatch*" was defined by the sum of the following three criteria: PWI (Tmax > 6 s) / DWI ration greater than or equal to 1.8, DWI less than 70 mL and PWI (Tmax > 10 s) less than 100 mL. In total, 92 patients were included in the MT group and 90 patients in the control group.

The intermediate analysis with 182 patients shows an improvement in functional outcomes on the Rankin scale at 90 days (OR at 2.8 (p<0.0001) in the thrombectomy group as well as a higher percentage of functionally independent patients (modified Rankin scale score between 0 and 2 of 45% *vs* 17%, p<0.001) compared to conventional treatment alone, equivalent to an NNT of 2.

At 90 days, the mortality rate was 14% in the group treated with endovascular thrombectomy and 26% in the conventional medical treatment only group (p=0.05), with no significant difference between the groups in respect of symptomatic intracranial haemorrhage frequency (7% *vs* 4%, p=0.75) or in respect of adverse effects (43% *vs* 53%, p=0.18).

The arterial recanalisation and reperfusion rates were higher in the MT arm (approximately 80%). The infarction volume was small (9 to 10 cc). There was no difference in efficacy between the different sub-groups, particularly between cases of wake-up stroke and those of known onset (median randomisation time 9.5 hours), between those eligible for Dawn criteria (62%) and those not eligible, the time to treatment, age, NIHSS, or CT scan or MRI selection.

The main limitation of these two studies is the premature discontinuation of the study at the first intermediate analysis thereby potentially overestimating the treatment effect. The findings suggest that endovascular thrombectomy would offer superior recovery of functional capacities at 90 days than a conventional medical treatment in patients with an onset of stroke symptoms between 6-16 hours (within 24 hours for DAWN).

### ► *American Heart Association / American Stroke Association* (AHA/ASA) guidelines (2018)

Following the publication of the DAWN and DEFUSE 3 trials, indicating that, in patients who have been carefully selected using advanced imaging, either by CT perfusion or magnetic resonance imaging, thrombectomy improves outcomes considerably, even up to 24 hours after the onset of symptoms, the AHA/ASA published new guidelines for the management of acute ischaemic stroke.

In selected patients with AIS within 6 to 16 hours of last known normal who have LVO in the anterior circulation and meet other DAWN or DEFUSE 3 eligibility criteria, mechanical thrombectomy is recommended (**class I (strong), level of evidence A**).

In selected patients with AIS within 6 to 24 hours of last known normal who have LVO in the anterior circulation and meet other DAWN eligibility criteria, mechanical thrombectomy is reasonable (**class IIa (moderate), level of evidence B-R**) (35).

### 4.1.2 Technical platform

#### ► Code of practice of MT in France, as per SFNR

According to the SFNR code of practice of MT in France, the thrombectomy procedure is performed in an angiography suite having the following minimum technical specifications:

- planar sensor of minimum size 30 cm, subtraction, *roadmap*;
- three-dimensional acquisition to provide table-based computed tomography type reconstruction capability;
- radioprotection means in compliance with the regulations in force;
- room meeting the same anaesthesia and asepsis requirements as those of an operating theatre;
- post-interventional monitoring suite including appropriate medical devices and environment (12).

#### ► "*Standards of practice in interventional neuroradiology*" recommendations

As per the joint recommendations of ESNR (*European Society of Neuroradiology)*, ESMINT (*European Society of Minimally Invasive Neurological Therapy)* and the neuroradiology division of UEMS (*European Union Of Medical Specialists)* published in 2017 (33), the optimal technical platform for the safe practice of interventional neuroradiology, including MT, is as follows:

- an interventional angiography suite suitable for the administration of a general anaesthetic under aseptic conditions similar to an operating theatre. Optimally, the procedures should be placed under imaging monitoring with a biplanar digital angiography system and flat-panel CT with three-dimensional image reconstruction capability;
- as a minimum, each suite should consist of a mobile table including a single C-shaped articulated arm, a high-resolution system and the digital subtraction angiography method. 3D imaging should be available in all diagnostic regimens, i.e. CT, MRI, catheter angiography, etc.;
- radioprotection measures should, in accordance with national and European regulations, be implemented with designated persons responsible for carrying out the necessary verifications.

### 4.1.3 Diagnostic neurological imaging capabilities

#### ► Technological assessment and HAS indicators

In its assessment report, "Endovascular intracranial artery thrombectomy", published in November 2016, HAS notes that the guidelines recommend introducing MT in combination with IV fibrinolysis, within six hours after the onset of symptoms for patients in whom anterior circulation artery occlusion should be confirmed by a non-invasive method as a first-line approach (CTA or MRA), before envisaging the MT therapy phase(2). The endpoint is to perform both vascular and cerebral parenchymal imaging, either by CT perfusion (CTP) or CT angiography (CTA), or by MRI, (diffusion, perfusion and magnetic resonance angiography) (47).

Based on the findings of the 2017 collection of 2016 data, indicators falling under "Initial stroke management" published by HAS in December 2017 (48), the weighted data in respect of institution activity volume demonstrate that 32.8% of patients would benefit from MRI as a first-line approach.

#### ► *American Heart Association / American Stroke Association* (AHA/ASA) guidelines (2018)

According to the authors, these guidelines support the overarching concept of stroke systems of care in both the prehospital and hospital settings. These systems should be established so that brain imaging studies can be performed within 20 minutes of arrival in the ED in at least 50% of patients who may be candidates for IV thrombolysis and/or MT (**class I (strong), level of evidence B-NR**).

In patients who are potential candidates for MT, imaging of the extracranial carotid and vertebral arteries, in addition to the intracranial circulation, is reasonable to provide useful information on

patient eligibility and endovascular procedural planning (**class IIa (moderate), level of evidence C-EO (expert opinion**).

Additional imaging beyond CT and CTA or MRI and magnetic resonance angiography (MRA) such as perfusion studies for selecting patients for mechanical thrombectomy in <6 hours is not recommended (**class III: no benefit, level of evidence B-R**).

In selected patients with AIS within 6 to 24 hours of last known normal who have LVO in the anterior circulation, obtaining CTP, DW-MRI, or MRI perfusion is recommended to aid in patient selection for mechanical thrombectomy, but only when imaging and other eligibility criteria from RCTs (DAWN and DEFUSE 3) showing benefit are being strictly applied in selecting patients for mechanical thrombectomy (**class I, level of evidence A**).

According to the authors, these guidelines are based on the best evidence currently available. In many instances, however, only limited data exist demonstrating the urgent need for continued research on treatment of acute ischaemic stroke (35).

#### ► *Royal College of Physicians "National clinical guideline for stroke"* guidelines (2016)

According to these clinical guidelines for stroke, urgent access to suitable imaging (non-contrast brain CT scan and CTA) is mandatory in order to select patients eligible for endovascular therapy. Indeed, referral for CT angiography is not a standard approach in all stroke units; systematic access to this imaging for all stroke cases should be increased rapidly (36).

#### ► Recommendations of the Society of Vascular and Interventional Neurology (SVIN) (2016)

For effective application of endovascular therapy of acute IS, current imaging criteria for comprehensive stroke centres should include 24/7 availability of CT and CT angiography, MRI and MR angiography, along with the ability to perform carotid duplex ultrasound, transcranial Doppler ultrasonography, extracranial ultrasonography, transoesophageal echocardiography and transthoracic echocardiography. All are critical for the management of the large vessel occlusion (LVO) AIS patient (38).

#### ► "*Standards of practice in interventional neuroradiology*" recommendations

As per the joint recommendations of ESNR (*European Society of Neuroradiology)*, ESMINT (*European Society of Minimally Invasive Neurological Therapy)* and the neuroradiology division of UEMS (*European Union Of Medical Specialists*) published in 2017 (33), a dedicated diagnostic neuroradiology department/section should be available on-site, and includes cutting-edge computed tomography and MRI systems.

### 4.1.4 INR unit organisation

#### ► *American Heart Association / American Stroke Association* (AHA/ASA) guidelines (2018)

It may be useful for primary stroke centres and other healthcare facilities that provide initial emergency care, including administration of IV alteplase, to develop the capability of performing emergency noninvasive intracranial vascular imaging to most appropriately select patients for transfer for endovascular intervention and to reduce the time to EVT (**class IIb (weak), level of evidence C-LD**).

Mechanical thrombectomy requires the patient to be at an experienced stroke centre with rapid access to cerebral angiography, qualified neurointerventionalists, and a comprehensive periprocedural care team. Systems should be designed, executed, and monitored to emphasise expeditious assessment and treatment. Outcomes for all patients should be tracked. Facilities are encouraged to define criteria that can be used to credential individuals who can perform safe and timely intra-arterial revascularisation procedures (**class I (strong), level of evidence C-EO (expert opinion)**).

All hospitals caring for stroke patients within a stroke system of care should develop, adopt, and adhere to care protocols that reflect current care guidelines as established by national and international professional organisations and state and federal agencies and laws (**class I (strong), level of evidence C-EO (expert opinion)**) (35).

### ► *European recommendations on organisation of interventional care in acute stroke* (EROICAS) (2016)

- Services should demonstrate established organisation at the centre to support rapidly instituted IV rt-PA use, team organisation of a level sufficient to support clinical trial participation. They should define a process for monitoring door-to-needle / groin puncture, and procedural duration times, and a governance process to ensure that these are reviewed (**quality of evidence: moderate, strength of recommendation: strong**).
- Services should include a neuroradiological/radiological department with experience with acute CT/MR interpretation including ASPECTS, and experience with CTA in acute stroke patients as a minimum additional imaging modality (**quality of evidence: moderate, strength of recommendation: strong)**.
- Operators and services should conform to minimum requirements for training, certification, and ongoing education for acute neurovascular procedures by national/European neurointerventional/radiological organisations and national statutory bodies (**quality of evidence: moderate, strength of recommendation: strong**) (37).

### ► Society of Vascular and Interventional Neurology (SVIN) consensus criteria (2016)

According to this U.S. consensus, comprehensive stroke centres performing endovascular AIS interventions need the capacity to triage and treat two simultaneous LVO AIS patients, thus necessitating the 24/7 availability of 2 neurointerventionalists, 2 stroke interventional labs and all associated support staff (e.g., radiology technicians, nursing staff).

Stroke centres have traditionally been focused on providing resources and optimising processes to improve delivery of thrombolytic medications, namely IV tPA. With the advent of cutting-edge clot retrieval devices and recent landmark endovascular stroke trials showing the functional outcome and mortality benefit of stroke intervention, the need for standardisation of stroke intervention labs within stroke centres across the country has become paramount.

In these recommendations for effective endovascular treatment of IS, the SVIN has compiled Stroke Interventional Laboratory Consensus (SILC) criteria to help standardise stroke intervention labs within stroke centres in an effort to promote high quality and rapid stroke care (38).

**Table 1. *Required elements for a Stroke Interventional Lab within a Stroke Centre* (SVIN-SILC: *Stroke Interventional Laboratory Consensus criteria*).**

| ***8M approach*** | |
|---|---|
| *Manpower* | Essential personnel including medical director, physicians, nurses and radiology technicians. |
| *Machines* | Appropriate angiographic equipment and facility level resources. |
| *Materials* | Medical device inventory, angiography room supplies and medications. |
| *Methods* | Standardised protocols for stroke workflow optimisation within hospital and within the stroke interventional lab. |
| *Metrics, volume* | Annual volume criteria for facilities as well as stroke interventionists to obtain as well as maintain certification or credentials. |
| *Metrics, quality* | Benchmarks for performance improvement and quality assurance with meaningful measures within the stroke interventional lab. |
| *Metrics, safety* | Radiation and procedural safety practices. |

| ***8M approach*** | |
|---|---|
| *Money* | Fair market value compensation standards for physician manpower needs to provide 24/7 coverage of stroke interventional labs. |

### ► TJC "*The Joint Commission*" Dedicated Neurointensive Care Unit and Expert Neurointensivist and Neurosurgical Management

The TJC requirements for comprehensive stroke centre management of aSAH patients and post-IV tPA AIS patients include a dedicated neurointensive care unit and 24/7 in-house expertise in cerebrovascular disease management. The medical management of the LVO AIS patient is equally complex, involving the prevention or management of secondary brain injury (e.g., ischaemia-related cerebral oedema and/or haemorrhagic conversion), reocclusion and the identification and

treatment of the underlying aetiology of the patient's presenting LVO. Integral components of such expert management also include early mobilisation and aggressive physical, occupational and speech/swallow therapy services. **Given the potential for complications** (intracerebral haemorrhage, perforation with subarachnoid haemorrhage, etc.) **that in some cases require emergent neurosurgical intervention** (e.g., external ventricular drain placement, haematoma evacuation, hemicraniectomy), **immediate availability of neurosurgical expertise**

**on a 24/7 basis is also critical to the management of these patients**.

As with previous studies showing improved outcomes for acute myocardial infarction patients treated in dedicated coronary care units, treatment of AIS patients, aSAH patients and head trauma patients in a dedicated neurological intensive care unit by a neurointensivist has been associated with improved neurological outcomes. These observations suggest that expert postoperative management of endovascular-treated LVO AIS patients is a critical aspect of achieving a favourable neurological outcome. **24/7 immediately available in-person expertise in cerebrovascular disease management by teams of vascular neurologists or neurocritical care specialists should be required for all endovascular AIS centres** (49).

### ► The necessary evolution of the comprehensive stroke centre model as per Society of Vascular and Interventional Neurology (SVIN) recommendations

Treatment with either IV tPA or endovascular therapy is extremely time-sensitive, and treatment delays (including those associated with patient transfer) need to be minimised as much as possible. As such, the availability of more MT-capable hospitals that can directly receive acute stroke patients from EMS (e.g., within 30-45 min of EMS triage) will prove central to effective treatment of these patients.

According to the SVIN, the guidelines should be revised to incorporate specific criteria pertaining to endovascular management of AIS. The current eligibility requirements for comprehensive stroke centres (for example, based on current TJC "*The Joint Commission*" criteria) include seven criteria: patient volume, advanced imaging capabilities, posthospital coordination, dedicated neurointensive care, a peer review process for quality control, participation in stroke research and reporting of performance measures.

As regards the minimum activity volume, higher-volume endovascular stroke centres have lower times to reperfusion and better outcomes with mechanical thrombectomy. Accordingly, TJC "*The Joint Commission*" requirements for annual patient volume at comprehensive stroke centres include 20 patients with subarachnoid haemorrhage and 25 AIS patients treated with IV tPA.

Given these TJC recommendations for aSAH and IV tPA treatment volumes, along with the prevalence of AIS compared to aSAH, where 85% of all strokes are ischaemic in nature, a minimum requirement of 25-30 MT-treated patients per year is recommended. Also, given the association of

operator volume and outcomes, each comprehensive stroke centre-affiliated neurointerventionalist should have a minimum of 10 MT procedures per year.

The required elements for comprehensive stroke centres, as per Society of Vascular and Interventional Neurology (SVIN) recommendations, are:

- 24/7 stroke neurology team available within 15 min either in person or via telemedicine (remote assessment);
- 24/7 neurointerventionalists available within 30 min;
- advanced imaging capabilities, including 24/7 availability of CT and CT angiography, MR and MR angiography and catheter angiography;
- 24/7 neurosurgery coverage available within 30 min;
- 24/7 NeuroICU and neurointensivists available within 30 min;
- capacity to handle two simultaneous acute LVO patients;
- two NeuroIR suites or stroke intervention labs (including associated teams of neuroradiologists, techs, etc.);
- two available neurointerventionalists;
- minimum annual volume requirements:
  - minimum of 30 endovascular MT cases/year;
  - minimum of 10 MT cases per operator per year;
  - minimum of 25 IV tPA cases/year (38).

### ► Hospital requirements of International Multi-society Consensus Document (2016)

According to the international multi-society[9] consensus document pertaining to the training guidelines for endovascular stroke intervention (50), successful treatment of the ELVO patient occurs within the framework of a multi-disciplinary team. The authors of these guidelines are of the view that it is critical that the patients be

treated in a centre, which has 24/7 access to the following:

- angiography suites suitably equipped to handle these patients, as well as equipment and capability to handle the complications;
- dedicated stroke and intensive care units (preferably dedicated neurointensive care unit), staffed by physicians with specific training in those fields;
- vascular neurology and neurocritical care expertise;
- neurosurgery expertise, including vascular neurosurgery;
- all relevant neuroimaging modalities (CT/CTA, MR/MRA, Trans-cranial Doppler [TCD]), including 24/7 access to CT and MRI.

### ► Royal College of Physicians "*National clinical guideline for stroke*" (2016)

According to *Royal College of Physicians* guidelines, an acute stroke service consists of either:

- a hyperacute stroke unit which cares for in-patients for up to 72 hours followed by transfer to an acute stroke unit;

[9] *American Academy of Neurological Surgeons / Congress of Neurological Surgeons* (AANS/CNS), *American Society of Neuroradiology* (ASNR), *Asian Australasian Federation of Interventional and Therapeutic Neuroradiology* (AAFITN), *Australian and New Zealand Society of Neuroradiology – Conjoint Committee for Recognition of Training in Interventional Neuroradiology* (CCINR) *representing the* RANZCR (ANZSNR), ANZAN *and* NSA*, Canadian Interventional Neuro Group* (CING), *European Society of Neuroradiology* (ESNR), *European Society of Minimally Invasive Neurological Therapy* (ESMINT), *Japanese Society for Neuroendovascular therapy* (JSNET), *Sociedad Ibero Latino Americana de Neuroradiologica* (SILAN), *Society of NeuroInterventional Surgery* (SNIS*), Society of Vascular and Interventional Neurology* (SVIN), *World Federation of Interventional and Therapeutic Neuroradiology* (WFITN).

- a stroke unit which provides both hyperacute and acute stroke care;
- a comprehensive stroke unit which provides all components of hyperacute, acute and rehabilitation stroke care.

All components of a specialist acute stroke service should be based in a hospital which has the requisite facilities to investigate and manage people with acute stroke and the medical and neurological complications. This requirement does not apply to services designed for stroke care in the rehabilitation phase.

Given that one in 20 strokes occur in people already in hospital, clinicians in high-risk clinical areas (e.g. cardiology wards, cardiothoracic units) should have a high level of awareness of the need to identify and treat acute neurological presentations urgently, including direct admission to a hyperacute stroke unit for emergency stroke treatments.

In this context, the *Royal College of Physicians* has issued the following definitions:

- a **specialist** is defined as a healthcare professional with the necessary knowledge and skills in managing people with stroke and conditions that mimic stroke, usually by having a relevant further qualification and keeping up to date through continuing professional development. This does not require the healthcare professional exclusively to manage people with stroke, but does require them to have specific knowledge and practical experience of stroke;
- a **specialist team or service** is defined as a group of specialists who work together regularly managing people with stroke and conditions that mimic stroke, and who between them have the knowledge and skills to assess and resolve the majority of problems. At a minimum, any specialist unit, team or service must be able to deliver all the relevant recommendations made in this guideline. This does not require the team exclusively to manage people with stroke, but the team should have specific knowledge and practical experience of stroke.

Moreover, the *Royal College of Physicians* is of the view that hyperacute stroke services providing endovascular treatment should participate in national stroke audit to enable comparison of the clinical and organisational quality of their services, and use the findings to plan and deliver service improvements (36).

### ► "*Standards of practice in interventional neuroradiology*" recommendations (2017)

As per the joint recommendations of ESNR (*European Society of Neuroradiology)*, ESMINT (*European Society of Minimally Invasive Neurological Therapy)* and the neuroradiology division of UEMS (*European Union Of Medical Specialists*) published in 2017 (33), interventional neuroradiology (including MT) should only be practised in healthcare institutions providing services and treatments to patients with neurological and other disorders on a full-time basis.

The equipment and staff required and which should be available on-site include:

- In-patient hospital beds;
- suitably equipped interventional angiography suite (see article 3), which forms part of a radiology/neuroradiology/neurointerventional department;
- a team of trained neuroradiologists/neurointerventionalists forming part of a radiology/neuroradiology/neurointerventional department;
- a dedicated diagnostic neuroradiology department (*cf.* section 4.2.5).

In order to be recognised as a facility approved to practise Interventional Neuroradiology (as defined above), the institution shall provide the services mentioned above on a full-time basis all year around (as a single institution or organised in a network of centres).

It is recommended that a recognised practice of Interventional Neuroradiology has a minimum workload[10] for each operator and for the institution as a whole. These figures should comply with

[10] The minimum workload is not defined in these guidelines.

local/national neuroradiological/neurointerventional guidelines and should be compatible with quality assurance directives.

Interventional neuroradiology should ideally be practised in INR teams in which exchange of experience, knowledge and research is possible. A specialist physician after having finished the training programme will be able to perform

procedures as described in article 1[11], in a team with other interventional neuroradiologists. Thus solitary practice of INR is not recommended.

### 4.1.5 Requirements for prescription and use issued by intracranial revascularisation medical device manufacturers

The manufacturers of revascularisation medical devices have not envisaged specific conditions for use or environmental requirements. They refer to those recommended by SFNR in 2015, in its code of practice of mechanical thrombectomy in France (12).

## 4.2 COPIL position on MT practice requirements

According to the opinions collected from the COPIL, the roll-out of MT as part of neurovascular services should also offer an opportunity to obtain a clearer definition of the human resources required and enforceable (by decree) for stroke centre operation, particularly in terms of MT capability so as to guarantee quality of care.

Moreover, as regards neurosurgery, neurovascular surgeons suggest that, optimally, it is desirable for this expertise to be on the same site. Nevertheless, it is acceptable, on a case-by-case basis, following an agreement between the off-site neurosurgery department, the stroke centre and the MT unit, for neurosurgery expertise not to be on-site. This proposal is based on the exceptional nature of the need for neurosurgery services for ischaemic stroke, on one hand, and, on the other, the possibility and need to have urgent transfer to the neurosurgery department. However, in the view of SFNR, the opening of new MT units should be envisaged in concert with regional health boards. In order to enable a wider distribution of thrombectomy and promote equality of access to care, these units should particularly have a sufficient number of interventionalists: at least three, and ideally four. As regards the activity volume requirements to obtain and retain accreditation and certification, SFNV suggests that MT should be carried out in units with a large caseload and trained practitioners. However, the activity thresholds set should be compatible with the reality in the field and should probably include not only MT procedures, but also other interventional neuroradiology activities. The essential increase in the number of practitioners capable of performing MT will necessarily reduce the number of individual procedures. Therefore, skills development should account for a set of procedures, possibly including the use of simulators. Moreover, capability for two simultaneous MT procedures is undoubtedly required for centres with very high volumes of activity. This scenario is exceptional in centres with moderate volumes of activity. In the view of SFNR, it would appear to be critical to define minimum activity volumes in order to obtain and retain certification for a new unit. The retention of accreditation of these new units should, for obvious safety reasons, be based on minimum activity volume requirements and an assessment of outcomes through participation in an exhaustive registry.

All of the stakeholders cite the findings of the DAWN and DEFUSE 3 trials with respect to the possibility of extending the indications beyond six hours for some patients which, in their view, endorse an increase in MT activity.

[11] Article 1: Interventional neuroradiology uses percutaneous and endovascular procedures to treat patients with diseases of the brain, sensory organs, head & neck, spinal cord, vertebral column and adjacent structures and the peripheral nervous system in adults and children. The interventional neuroradiology techniques conventionally use particularly include mechanical thrombectomy.

**Findings on MT practice requirements**

Practice requirements were addressed in part in the first part in respect of MT efficacy and safety. The guidelines analysed within the scope of this assessment relating to the organisational aspect can be used to describe the technical platform for the practice of MT, the diagnostic neurological imaging capabilities required, and the organisation of a unit practising MT. They have been drawn from the best evidence currently available and on the opinion of the experts consulted. As a general rule, these guidelines are in agreement and recommend the following points.

**Therapeutic decision**

- Note: MT is indicated either, from the outset, in combination with intravenous (IV) thrombolysis, as a second-line procedure (after IV thrombolysis treatment failure or on its own in the event of contraindication to IV thrombolysis), within six hours after the onset of symptoms for acute IS patients, associated with anterior circulation LVO visible via imaging.
- In view of the findings of the recent randomised controlled trials (RCTs), DAWN (27) and DEFUSE-3 (28), two indication extensions may be proposed:

  - as such, MT may be recommended in selected patients with AIS within 6 to 16 hours of last known normal, presenting with LVO in the anterior circulation and meeting the eligibility criteria of the DAWN or DEFUSE-3 trials;
  - MT may also be recommended in selected stroke patients within 6 to 24 hours of last known normal, presenting with LVO in the anterior circulation and meeting the eligibility criteria of the DAWN trial.
- Vascular occlusion should be diagnosed non-invasively as a first-line approach (CTA or magnetic resonance angiography) before envisaging the MT therapy phase.
- The decision to carry out MT should be made by a multidisciplinary team including at least one neurologist and/or a medical practitioner with neurovascular disease expertise from an on-site stroke centre and a medical practitioner qualified to perform MT.
- The choice of anaesthetic procedure is decided jointly by the anaesthetist and the interventional neuroradiologist or the medical practitioner qualified to perform MT. This choice is made on the basis of a personalised assessment of the patient's clinical characteristics and risk factors, as well as the technical performances of the procedure. The endpoint is to carry out MT under optimal conditions for the patient without reducing the time to MT treatment.

**Diagnostic neuroradiology unit**

In order to be able to indicate MT, institutions must have the following diagnostic imaging capabilities and equipment:

- 24/7 access to CT scans (perfusion and angiography), MRI (brain MRI and magnetic resonance angiography);
- organisations should enable brain imaging examinations to be carried out in a timely manner following arrival at the emergency department for at least 50% of patients who are potential candidates for intravenous thrombolysis and/or MT;
- imaging capability of the extracranial and vertebral carotid arteries, in addition to the intracranial circulation, in order to assess the patient's eligibility for the endovascular procedure.

**MT unit**

The technical platform for the practice of MT includes:

- an interventional angiography suite consisting of a floating table with a dedicated cradle enabling rotational 3D acquisitions;
- this interventional angiography suite should enable the administration of a general anaesthetic under aseptic conditions identical to those of an operating theatre;
- radioprotection measures should be implemented, in accordance with the regulations currently in force.

**Link between practice of MT and stroke centre**

The MT procedure should be an integral part of neurovascular services based on diagnostic imaging and neurological opinion. This implies that, on one hand, all patients who are candidates for MT should be previously admitted to a stroke centre, and, on the other, that the MT procedure may be only be envisaged in a healthcare institution with an accredited stroke centre, in accordance with the criteria set out in the regulations in force (*cf.* section 1.2.2).

These healthcare institutions should have the following:

- a stroke centre-affiliated vascular neurology team available 24/7, physically present on-site or accessible via telemedicine;
- 24/7 MT interventionalists;
- a team of radiologists available 24/7, present on-site or via telemedicine and advanced imaging equipment (*cf.* "diagnostic imaging capability" section);
- neurosurgical care available 24/7 on-site or in agreement with another institution approved for this activity;
- an NICU unit available 24/7;
- three MT interventionalists (trained for MT management within the framework of an MT or INR unit);
- standardised protocols for the management of patients from their arrival at the institution;
- expert postoperative management of IS patients associated with LVO.

Moreover, these healthcare institutions should also:

- have radioprotection measures for patients and operators;
- have an interfacility transfer protocol (with other stroke centres) in accordance with the regional organisation defined by the regional health board;
- participate in the healthcare professional registry of practices, in accordance with HAS recommendations;
- complete HAS indicators for the improvement of the quality and safety of care in respect of initial stroke management.

# 5. Assessment of team composition and training of professionals involved in care

As discussed in part in the first part of the assessment of endovascular intracranial artery thrombectomy, MT is currently carried out by a trained and experienced interventional neuroradiologist, meeting the licensing requirements defined by the order of 15 March 2010 (art. D.6124-149 of the public health code) (2).

A number of identified publications (essentially clinical practice guidelines) document the various stakeholders involved in mechanical thrombectomy and the training and qualifications required in more detail.

## 5.1 Data from the literature

### 5.1.1 Mechanical thrombectomy stakeholders

#### ► SFNV recommendations on the role of mechanical thrombectomy (2015)

According to these recommendations, the decision to carry out MT should be taken by a multidisciplinary team including at least:

- one neurologist and/or medical practitioner with neurovascular disease expertise;
- one interventional neuroradiologist and/or practitioner, meeting the licensing requirements defined by the order of 15 March 2010 (art. D.6124-149 of the public health code) (13).

#### ► SFNR code of practice of MT in France (2016)

As per this code of practice, the stakeholders in MT are:

- the interventional neuroradiologist: according to the decrees, the thrombectomy procedure should be carried out by "radiodiagnostic and medical imaging specialists or, failing that, neurosurgery or neurology specialists, with training and experience in endovascular interventional neuroradiology procedures and meeting the following requirements:
  - holder of a university or interuniversity qualification in diagnostic and therapeutic neuroradiology, including two years of theoretical training;
  - continuous practical training for at least three years including one year in diagnostic radiology and two years in interventional neuroradiology in an institution carrying out more than 80 endovascular interventional neuroradiology procedures annually".
- an anaesthetist and resuscitation specialist and a state-qualified anaesthesia nurse (IADE);
- at least two other staff members, including a radiographer; the second person is, as required, either a medical practitioner, a nurse, or a medical radiographer (12).

#### ► "*Standards of practice in interventional neuroradiology*" recommendations

As per the joint recommendations of ESNR (*European Society of Neuroradiology)*, ESMINT (*European Society of Minimally Invasive Neurological Therapy)* and the neuroradiology division of UEMS (*European Union Of Medical Specialists)* published in 2017, the operational guidelines are as follows (33).

In order to provide a comprehensive service, the necessary medical staff should include:

- a minimum of two, optimally four, physicians with particular qualification or other acceptable training in interventional neuroradiology;
- anaesthetists with experience in caring for patients during interventional neuroradiology procedures.

It is recommended that each intervention is performed with the immediate availability of a minimum of the following staff:

- a primary interventional neuroradiologist / neurointerventionalist;
- a surgical assistant;
- a radiographer;
- a nurse or a nurse assistant;
- an anaesthetist, if required, according to local regulations (33).

### ► Royal College of Physicians and Surgeons of Canada (FRCPC) of the neuroscience department of the University of Montreal (2017)

The Royal College of Physicians and Surgeons of Canada drafted an expert opinion on endovascular therapy. In its view, this therapy requires careful implementation and optimisation in real-world settings to provide all eligible patients with this new standard of care. The stroke physician must work in close collaboration with the neurointerventionalist to optimise the speed, efficiency, and safety of endovascular therapy, elements which are critical to enhancing patient outcomes. A proposed division of physician roles is shown in table 2, with emphasis on parallel rather than serial workflow.

**Table 2. Respective roles of the stroke physician and the neurointerventionalist before, during, and after endovascular therapy for acute ischaemic stroke.**

| Stroke Physician | Neurointerventialist |
|---|---|
| Verify last seen normal/stroke onset time | |
| Determine baseline functional status and obtain medical history | |
| Determine current clinical deficits - neurological examination (NIHSS) | |
| Identify patients as a possible EVT case (high NIHSS score, good premorbid status) and alert neurointerventional team | Determine angiography suite availability |
| Assess and manage haemodynamics and medical comorbidities in view of potential reperfusion therapy | |
| Establish if there are contraindications to intravenous thrombolysis (alteplase) | |
| Review CT and CTA (or MR and MRA) and determine whether patient is EVT candidate | Review CT and CTA (or MR and MRA) and determine whether patient is EVT candidate |
| Initiate alteplase (if indicated) as quickly as possible | Prepare EVT plan based on arterial anatomy |
| Manage all patients not candidates for EVT (e.g., stroke mimic, no large-vessel occlusion, etc.) | Interventionalist signs off the case |
| Discuss EVT with patient and family if possible | Discuss EVT with patient and family if possible |
| Obtain verbal consent for EVT if possible | Prepare angiography suite for procedure |
| Determine potential need for anaesthesia (general or conscious sedation) and consult anaesthesia as required | Determine potential need for anaesthesia (general or conscious sedation) |
| Manage conscious sedation or assist anaesthetist as required | Perform EVT procedure |
| Monitor vital signs and haemodynamics during procedure | Perform EVT procedure |
| Discuss therapeutic options (e.g., cervical carotid stenting) and termination of EVT when difficult | Discuss therapeutic options (e.g., cervical carotid stenting) and termination of EVT when difficult |
| Collect and provide quality metrics | Collect and provide quality metrics |

| Stroke Physician | Neurointerventialist |
|---|---|
| Manage postprocedural medical issues (e.g., BP management, antithrombotic management) | Collaborate on postprocedural medical management |
| Document evolution of patient in chart and order appropriate investigations | Aid in management of arterial puncture-site complications |
| Organise any relevant consults (medical, multidisciplinary) | |
| Transfer to acute care/stroke unit | |

### 5.1.2 Medical practitioner training and qualifications in MT

The need for team training has been reiterated by several authors. According to the French review by Daubail *et al.*, it will be necessary to train general practitioners, emergency doctors, neurologists, radiologists and emergency ward nurses. This professional training, focused on stroke triage, will depend on the size of the stroke team, which often depends on the urban or rural location of the unit (29).

According to the French Radiology Society, endovascular clot retrieval is a complex procedure that needs to be performed as quickly as possible. It requires an experienced, suitably trained and skilled team. As such, the practice of MT should be reserved for specialist units so that teams can develop and maintain their expertise by carrying out a sufficient number of procedures.

The practice of interventional radiology (IR) differs from country to country, essentially due to local, particularly historic, factors. Schematically, there are two opposable approaches:

- the approach applied in the English-speaking world which officially recognises IR as a separate radiological specialty to diagnostic radiology;
- the French and European approach which separates radiology according to organ specialties (neuroradiology, cardiovascular, digestive tract, etc.), combining diagnostic radiology and interventional radiology. This approach holds the majority, regardless of the type of practice, public or private.

In France, the second approach has been adopted by the bodies representing the profession: SFR (learned society), CERF (college of teachers), FNMR and SRH (private and public professional associations), under the umbrella of the Professional Radiology Council (G4) conference (51).

#### ► Order of 15 March 2010 defining the requirements for proof of training and experience in endovascular interventional neuroradiology procedures

The medical staff envisaged in article D.6124-149 (para. 1) must provide proof of qualification as a radiodiagnostic and medical imaging specialist or, failing that, qualification as a neurosurgery or neurology specialist, and of training and experience in endovascular interventional neuroradiology procedures meeting the following requirements:

- holder of a university or interuniversity qualification in diagnostic and therapeutic neuroradiology, including two years of theoretical training;
- continuous practical training for at least three years including one year in diagnostic radiology and two years in interventional neuroradiology in an institution carrying out more than 80 endovascular interventional neuroradiology procedures annually (11).

#### ► Order of 21 April 2017 pertaining to the knowledge, skills and training models in respect of post-graduate diplomas defines the list of these diplomas and post-graduate cross-disciplinary specialist training options in medical studies

2017 saw the entry into force of the post-graduate reform of medical studies, now solely based on post-graduate diplomas (DES). As such, the order of 21 April 2017 defines the modalities, different phases and models of post-graduate diplomas for all medical specialties. It also specifies the op-

tions for each post-graduate diploma, as well as the specialised cross-disciplinary training (SCDT) open to a number of medical specialties:

"*Art. 1. – Students entering the post-graduate phase of medical studies from the 2017-2018 academic year register for one of the post-graduate diplomas (DES) listed in annex I of this order.*

*Post-graduate diplomas entitle the holder to a specialist qualification corresponding to the title of the diploma. Each post-graduate diploma is the subject of a training model, appended to the present order, including, in particular, the duration of the training, teaching programme, duration and nature of the internships to be completed, as well as the specific skills and knowledge to be acquired in addition to the basic skills and knowledge provided for in articles 2 to 4 of this order.*

*Art. 2. – During phase 1 known as the foundation phase, the student acquires knowledge in the chosen specialty and builds a first foundation of skills required for clinical practice.*

*Art. 3. – During phase 2 known as the immersion phase, the student increases the knowledge and skills acquired during the foundation phase required to practise the specialty.*

*Art. 4. – During phase 3 known as the consolidation phase, the student consolidates all of the clinical knowledge and skills acquired during the first two phases and required to practise the specialty. The student also prepares his/her occupational integration*" (52).

### ► Post-graduate diploma in "radiology and medical imaging"

#### General training aims

The aim of this post-graduate diploma is to enable its holder to:

- provide care for patients in all areas of imaging, via all diagnostic medical imaging regimens;
- conduct interventional radiology procedures apart from those envisaged in the scope of the advanced interventional radiology option.

#### Total duration of post-graduate diploma in "radiology and medical imaging"

The total duration of this post-graduate diploma is ten semesters, including at least six semesters as an intern with academic supervision, as defined in article 1 of the order of 21 April 2017 and at least three semesters as an intern without academic supervision.

#### "Advanced interventional radiology" option offered in the post-graduate diploma in "radiology and medical imaging"

The aim of this option is to provide training and expertise in "complex, advanced interventional radiology (IR) procedures", separate from so-called "basic" IR procedures, acquired through all post-graduate diplomas in radiology in the immersion phase. These complex procedures are defined by set-up requirements (SR), specific technical operating requirements (TOR), and the duration of their training. This option takes place in radiology departments with teams qualified to carry out complex IR procedures in respect of the organ IR subspecialties practised. The frame of reference of these procedures, drafted under the aegis of the National Radiology Council by the Federation of interventional radiology of the French Radiology Society (SFR) and CERF, can be found on the CERF website.

MT is taught within the scope of initial medical training within the framework of this option.

#### Duration: four semesters

The "advanced interventional radiology" option of the post-graduate diploma in "radiology and medical imaging" brings the duration of the training to six years.

#### Knowledge

Teaching modules in one to three organ disease areas for IR. As regards interventional neurology, the training should be in compliance with the decree in respect of practice in force (order of 15

March 2010 defining the requirements for proof of training and experience in endovascular interventional neuroradiology procedures provided for in article D.6124-149 of the public health code).

**Skills to be acquired (minimum number of second-line and first-line procedures defined by procedure type)**

- Competency in indications for advanced IR, multidisciplinary review meeting discussions, announcement and information in consultation in one to three organ disease areas with advanced IR.
- Training on practical skills (percutaneous, endovascular, root canal) in respect of the procedures performed, equipment, radiological guidance, IR unit operation (radioprotection, image processing, health and safety, equipment management, interdisclipinary cooperation and downstream link management, etc.), in one to two three organ disease areas with advanced IR.
- Knowledge of outcomes, follow-up and complication management with advanced IR.
- As regards interventional neurology: training in compliance with the decree in respect of practice in force (order of 15 March 2010 defining the requirements for proof of training and experience in endovascular interventional neuroradiology procedures provided for in article D.6124-149 of the public health code).
- Students shall become increasingly self-reliant within the framework of this option.

**Internships**

*Number and duration of approved internships for advanced interventional radiology*

Four internships are required, lasting one semester at a hospital facility approved primarily for radiology and medical imaging, with an advanced interventional radiology activity, and with a team qualified for advanced IR procedures in respect of the IR subspecialties practised.

*Approval criteria of approved internships for advanced interventional radiology*

In addition to the provisions of article 34 of the order of 12 April 2017 pertaining to the organisation of the post-graduate phase of medical studies, the approval committee shall take into consideration:

- the qualification of the host team in advanced interventional radiology procedures in respect of the interventional radiology subspecialties in question;
- supervision by one senior interventional radiology per student;
- attendance of multidisciplinary review meetings, morbi-mortality meeting reviews and pre- and post-interventional consultations.

*Title of specialised cross-disciplinary training (SCDT)*

Within the scope of his/her career plan, and in view of healthcare needs and the training offer, the student may be conduced to apply for specialised cross-disciplinary training (SCDT).

**► Interuniversity diploma (DIU) in diagnostic and therapeutic neuroradiology**

The interuniversity diploma (DIU) in diagnostic and therapeutic neuroradiology is a training course provided by the French Neuroradiology Society (SFNR).

"It is essentially intended for junior doctors aiming to practise diagnostic and/or interventional neuroradiology. This post-graduate course of high academic quality taught by high-quality lecturers from all regions in France is divided into twelve seminars. It covers the various brain, bone marrow, spinal, ENT, maxillofacial and orbital conditions that neuroradiologists are liable to encounter in their clinical practice. The interuniversity diploma in diagnostic and therapeutic neuroradiology also includes a considerable amount of teaching in relation to both vascular and spinal interventional neuroradiology (INR).

The interuniversity diploma in diagnostic and therapeutic neuroradiology validates the two-year theoretical training required to be able to practise interventional neuroradiology in a senior medical role (order of 15 March 2010; decree No. 2007-366 of 19 March 2007). It is open to trainee radiologists, neurosurgeons and neurologists with a clearly defined plan to practise neuroradiology with a view to practising for at least two years in a neuroradiology department for DNR, and for one year in a DNR department + years of INR to practise INR"[12].

### ► BSNR *(British Society of Neuroradiologists)* "*Training guidance for mechanical thrombectomy"* guidelines (2017)

In the United Kingdom, the members of the *UK Neurointerventional Group* (UKNG) and of the *British Society of Neuroradiologists* (BSNR) drafted, under the aegis of the *Royal College of Radiologists* (RCR), guidelines on the training and expertise required to practise mechanical thrombectomy (42).

#### Components and duration of INR training pre-CCT (*Certificate of Completion of Training*)

*Interventional neuroradiology trainee*

- Core radiology training for 36 months.
- Advanced neurology and neuroscience training for 12 months.
- INR radiology training for 24 months.

[12] http://www.sfnr.net/ressources-formation/diu-neuroradiologie

*Interventional radiology trainee*

An IR trainee wishing to convert to INR would need a minimum of 2 years of training time in diagnostic and interventional neuroradiology (i.e. would need to commence INR training by the start of ST5[13]).

*Non-radiology trainee wishing to convert to INR training*

As-yet, there is no RCR/GMC (*General Medical Council*) approved path for trainees from other clinical specialties to enter into fast-track radiology training. At-present, trainees can either retrain in radiology, or alternatively complete their specialty training and retrain post-CCT.

### Components and estimated duration of INR/MT training post-CCT

Diagnostic and INR training can run concurrently.

*Interventional radiologist post-CCT*

- Advanced neuroimaging and neurosciences: 6 months.
- INR training: 12-18 months.
- Total: 12 to 24 months.

*Diagnostic neuroradiologist post-CCT*

- INR training: 18-24 months.
- Total: 18 to 24 months.

*Neurologist or neurosurgeon post-CCT*

- Core / advanced neuroimaging: 12 months.
- INR training: 24 months.
- Total: 24 months.

*Cardiologist post-CCT*

- Core / advanced neuroimaging and neuroscience training 12 months.
- INR training 24 months.
- Total: 24 months.

### Training centre requirements

INR training can only be provided in a recognised neuroscience training centre or network, by experienced INRs.

Training centres should be recognised by the RCR (via subspecialty interest groups, UKNG and BSNR) and GMC (*General Medical Council*).

A training centre must include a team of at least two INRs.

The training centre must perform a **minimum of 100 cerebral neurointerventional cases / year** and the case-mix should include acute stroke (a high volume of stroke work is an implicit training requirement, but it is impractical to set a specific target before anticipated MT service development).

### Curricular content for MT/INR training

According to the *British Society of Neuroradiologists*, there are potential disadvantages to setting targets, the achievement of which may not necessarily reflect an individual's competence. Howev-

[13] *Speciality training* (*postgraduate training in the UK*).

er, the following section outlines procedural activity levels suggested by training bodies within and outside the UK as guidance.

### *Diagnostic imaging*

A neuroradiology trainee typically reports a **minimum of 40 mixed CT/MR cases per week**, resulting in a low estimate of 1600 cases in a year.

### *Arterial recanalisation procedures (MT)*

This procedure demands rapid arterial access, rapid navigation of a guide catheter system to a stable position, accurate assessment of arterial anatomy, rapid navigation of a microcatheter system and or suction thrombectomy catheter intracranially and safe deployment and retrieval of a *stent retriever*.

The operator must appreciate what equipment is best suited to the anatomy and the procedure, where and how to navigate blindly and what manipulation the arterial tree will tolerate (cerebral vessels are thin-walled, mobile / deformable, angulated and take multiple variable branching patterns).

The operator must be equipped with the necessary technical and decision-making skills to be able to continuously re-assess progress, able to modify the strategy where appropriate, able to decide when an effective treatment has been achieved and able to detect and manage complications promptly.

In the clinical setting (often post IV thrombolysis), the consequences of vessel perforation, vessel dissection or rupture (due to inadvertent navigation into a perforator, small pial arterial branch, or aneurysm), may be fatal. Inefficient technique will also increase procedural time, reducing benefit and increasing the risk of complications such as clot embolisation to another vessel territory.

### *Minimum recommended experience as per the BSNR (British Society of Neuroradiologists) compared to that recommended by several learned societies in the USA*

**Table 3. Minimum recommended experience.**

| Institution | Experience | Reference |
|---|---|---|
| SIR | 200 selective angiograms of which 50 should be cervico-cerebral.<br>30 procedures using microcatheters and micro guidewires.<br>5 stroke lysis cases under the (remote) supervision of a proctor who has performed at least 10 cases. | *Training Guidelines for Intra-arterial Catheter-Directed Treatment of Acute Ischaemic Stroke: A Statement from a Special Writing Group of the Society of Interventional Radiology* (SIR). J Vasc Interv Radiol 2009;20:1507-1522 (50) |
| AAN, AANS / CNS, SNIS, SVIN | 1 year of INR fellowship with the full range of INR procedures. | *Performance and training standards for endovascular ischaemic stroke treatment.* Meyers PM *et-al.* J NeuroInterv Surg 2009;1:10-12 (53) |
| AAN, AANS / CNS, SNIS, SVIN | 100 cerebral angiograms.<br>30 intracranial microcatheter navigations.<br>10 mentored stroke therapies*. | *Performance and training standards for endovascular ischaemic stroke treatment.* Meyers PM *et-al.* J NeuroInterv Surg 2009;1:10-12 (53) |
| UKNG / BSNR | 30 MT procedures | *BSNR (British Society of Neuroradiologists) training guidance for mechanical thrombectomy.* Clin Radiol 2017;72,e11–175, e18. (54) |

**the advisory figures provided relate primarily to intra-arterial thrombolysis (2009) and are not directly comparable to current MT techniques (which would be associated with higher risks in less experienced hands).*

*Maintenance of skills*

Any practitioner performing MT must work in a centre that has direct access to multidisciplinary care with cover from:

- stroke services;
- anaesthetics;
- neuro critical care and neurosurgery;
- vascular surgery.

The centre must have 24/7 provision of CT/CTA and DSA angiography / interventional facilities.

Moreover, it is essential that qualified practitioners work in institutions with a sufficient case-referral rate to maintain skills in clinical practice.

The operator must perform **no less than 40 intracranial neurovascular procedures / year** (minimum 1 per working week, excluding diagnostic catheter angiography and isolated carotid artery stenting) to maintain competencies (42).

### ► UEMS (*European Union of Medical Specialists*) training charter

According to an editorial of EJMINT (*The Journal of the European Society of Minimally Invasive Neurological Therapy*) dated 2013, the training charter indicates that "all physicians (singularly neurologists, neurosurgeons, radiologists and neuroradiologists) can be trained in INR. It seems essential for the future of INR that all specialists receive the same training and that individual specialities do not organise their own training (interventional neurology, endovascular neurosurgery, interventional neuroradiology, etc.)". The training charter is based on four years' full-time training including one year of clinical neuroscience, one year of diagnostic neuroradiology and two years of INR (55).

### ► *European recommendations on organisation of interventional care in acute stroke* (EROICAS) (2016)

According to EROICAS, mechanical thrombectomy should be performed by physicians

competent in intracranial endovascular procedures. This competence is based on:

- proven capacity to perform, conduct, and interpret standard diagnostic neuroradiology (CT, MR, multimodal-imaging) for appropriate case selection;
- proven capacity to perform, conduct, and interpret standard intracranial endovascular procedures as well as management skills for procedural complications;
- skills in interdisciplinary management of haemorrhagic and ischaemic stroke patients with

  stroke physicians or neurologists/neurosurgeons in stroke centres. Treatment in the context of an acute stroke unit is an option in geographically remote regions;
- meeting the minimum requirements for training, certification, caseload, and ongoing education for acute neurovascular procedures by national/European neurointerventional/radiological organisations and national statutory bodies (e.g. certification by a European or National Certificate/Diploma/Master);
- continuous updating of the interventional neuroradiology (INR) diagnostic and therapeutic

  methods and skills (quality of evidence: moderate, strength of recommendation:

  strong) (37).

## ► International multi-society consensus (2016)

A number of learned societies[14] issued an international consensus on the definition of suitable training for medical practitioners required to carry out endovascular procedures on acute IS patients (39).

These guidelines are based on previous diagnostic cerebral angiography, carotid stent and acute stroke treatment training, performance standard and accreditation documents written and approved by a number of learned societies[15] in 2010 (40) and 2012 (41).

As such, physicians providing intra-arterial treatment for acute stroke are required to have appropriate training and experience for the performance of neuroangiography and interventional neuroradiology.

These cognitive requirements consist of baseline training and qualifications as well as ongoing professional education, which are essential for safe and efficient patient management. The authors point out that these qualifications are for new practitioners who are not currently performing acute stroke intervention with mechanical thrombectomy. They state that there are current practitioners (who are board-certified or board-eligible in

radiology, neurology or neurosurgery) who may have trained prior to the establishment of

formal training pathways, and have acquired the necessary skills listed below to safely and effectively treat these patients.

### Baseline training and qualifications

#### *Residency training (in radiology, neurology or neurosurgery)*

The pathway should include documented training in the diagnosis and management of acute stroke, the interpretation of cerebral arteriography and neuroimaging under the supervision of a board-certified neuroradiologist, neurologist or neurosurgeon.

The residency programme and supervising physicians should be accredited according to national standards as they pertain to the countries involved. Those physicians who did not have adequate such training during their residencies must spend an additional period (**typically one year**) by training in clinical neurosciences and neuroimaging, focusing on the diagnosis and management of acute stroke, the interpretation of cerebral arteriography and neuroimaging prior to their fellowship in neuroendovascular interventions.

#### *Dedicated training in interventional neuroradiology*

Training in INR (also termed Endovascular Neurosurgery or Interventional Neurology) is conducted under the direction of a Neurointerventionalist (with neuroradiology, neurology or neurosurgical training background), at a high-volume centre. It is preferred that this is **a dedicated year, which occurs after graduating from**

[14] *American Academy of Neurological Surgeons/Congress of Neurological Surgeons* (AANS/CNS)*, American Society of Neuroradiology* (ASNR), *Asian Australasian Federation of Interventional and Therapeutic Neuroradiology* (AAFITN), *Australian and New Zealand Society of Neuroradiology – Conjoint Committee for Recognition of Training in Interventional Neuroradiology* (CCINR) *representing the* RANZCR (ANZSNR), ANZAN *and* NSA, *Canadian Interventional Neuro Group* (CING), *European Society of Neuroradiology* (ESNR), *European Society of Minimally Invasive Neurological Therapy* (ESMINT), *Japanese Society for Neuroendovascular therapy* (JSNET), *Sociedad Ibero Latino Americana de Neuroradiologica* (SILAN), *Society of NeuroInterventional Surgery* (SNIS), *Society of Vascular and Interventional Neurology* (SVIN), *World Federation of Interventional and Therapeutic Neuroradiology* (WFITN).

[15] *Society of NeuroInterventional Surgery* (SNIS), *American Academy of Neurology* (AAN), *American Association of Neurological Surgeons/Cerebrovascular Section* (AANS/CNS), *and Society of Vascular & Interventional Neurology* (SVIN).

**residency**. A training programme accredited by a national accrediting body is also strongly preferred but not required. Within these programmes, specific training for intra-arterial therapy for acute ischaemic stroke should be performed, including obtaining appropriate access even in challenging anatomy, microcatheter navigation in the cerebral circulation, knowledge and training of the use of stroke-specific devices and complication avoidance and management.

#### Maintenance of physician qualifications

It is vital that the physician have ongoing stroke specific continuing medical education. **A minimum of 16 hours of stroke specific education every 2 years is suggested**. Individual physician outcomes should conform to national standards and institutional requirements. In addition, the physician should participate in an ongoing quality assurance and improvement programme.

The goals of this quality assurance programme for stroke therapy would be to monitor outcomes both in the peri-procedural period and at 90 days. The quality assurance programme must review all emergency interventional stroke therapy patients. In addition, participation in a national quality improvement registry, when available, is also encouraged. Outcomes should be tracked and recorded. While threshold levels for recanalisation, complication rates, etc. have yet to be established, the guidelines suggest the following as a minimum:

- successful recanalisation (modified TICI 2b or 3) in at least 60% of cases;
- embolisation to new territory of less than 15%;
- symptomatic intracranial haemorrhage (i.e. parenchymal haematoma on imaging with clinical deterioration) rate less than 10%.

### 5.1.3 Regional certified CME process initiative: example of Nouvelle-Aquitaine region

This section reports the first meeting launching a regional discussion; it in no way represents a training process for interventional radiologists.

With a view to addressing the current priority of the network which aims to match human resources to ensure equality of access to care, reinforce the teams in place and attain long-term sustainability, Berge *et al.* 2016 (56) undertook an initiative in the Nouvelle-Aquitaine region based on conducting an audit of existing teams at the three university hospitals (CHUs), with a view to achieving by 2018, an expansion of activity to the three CHUs and to the three general hospitals (CHGs), in which non-INR interventional radiologists already provide an on-call service. The training of all these new interventional neuroradiologists will be shared between the three CHUs in this large region. The duration of the training required on a regional level will be dependent on the INR upgrade programme model required for these general hospital practitioners specialised in interventional radiology.

The criteria for this training are currently being studied on both a European and French level and will combine theoretical and practical training and undoubtedly Stroke-MT-specific national interuniversity diploma examination credentials. However, this continuous education is aimed at practitioners with previous experience in the interventional field, the credentials of which will taken into account in their accreditation. In the Nouvelle-Aquitaine region, this training for general hospital practitioners consists of a choice shared among the regional health boards who are opting for a rapid local roll-out of new MT units, involving neurologists from local stroke centres and the CHU and neuroradiologists from the three CHUs in the region. In order to set this process in motion and involve future radiologists from CHGs in this training project, it is proposed to organise in Bordeaux, in late January and late March, MT awareness and introduction workshops. This training, which is practical (introduction to equipment, *flow model*, porcine animal model) and above all theoretical (ten hours of lectures), will cover the physiopathology and clinical aspects of stroke, patient selection for fibrinolysis and MT, SFNR/SFNV guidelines, the patient pathway, the review of the literature and clinical cases.

## 5.2 COPIL position on clinical and technical skills

The neuroradiologists and vascular neurologists included in the COPIL would like to point out that it should be possible to acquire INR skills as part of initial training or continuous training. At the present time, interventional neuroradiology skills are regulated by the order of 2010 which stipulates three years of practical training and the achievement of an interuniversity diploma. These skills are accessible to radiologists, neurologists, and neurosurgeons. The initial training curriculum should be the same for all practitioners seeking to acquire INR skills, regardless of the original specialty.

As per SFNV,

- **Initial training**
  - the reform of post-graduate medical studies implemented from the 2017-2018 academic year stipulates a single diploma, the DES. For radiology, an "interventional radiology" option has been created which prolongs the duration of training by one year and appears to be suitable for providing interventional neuroradiology skills. The order of 2010 stipulates a DIU, a diploma which is not theoretically required in order to be awarded the DES as it is based on continuous education. Furthermore, the order of 2010 stipulates at least three years of continuous practical training, including one year of diagnostic neuroradiology and two years of interventional neuroradiology, which is not feasible within the DES framework;
  - the 2017 reform also enables the creation of specialised cross-disciplinary training (SCDT) consisting of shared expertise between different disciplines. Such training could enable other disciplines (neurology, neurosurgery, in particular) to acquire skills in interventional neuroradiology, subject to a sufficient training duration, or a sufficient number of cases (regardless of duration). SCDT should make it possible to simplify the training of other professionals. The requirements for such SCDT remain to be discussed for the stakeholder, just one additional year would not be sufficient for other disciplines;
  - besides the duration of practical training in interventional neuroradiology, neuroradiologists are of the view that it is critical to emphasise skills defined by a number of cases treated independently and the verification of such skills.
- **Continuous training**

In the view of SFNR, an interuniversity diploma (DIU) would undoubtedly be appropriate in addition to practical training adapted to each candidate's profile. Carrying out and mastering all INR procedures are obviously critical for skills development. An expansion of the pool of professionals is under way, as demonstrated by the number of junior practitioners involved in this three-year training. The reform of post-graduate medical studies proposes a two-year advanced interventional radiology option providing a foundation for INR procedures. This junior INR training process should be bolstered by the creation of positions of assistants (initially), and subsequently of practitioners dedicated to interventional neuroradiology in each INR centre. However, this expansion may not be sufficient for an intermediate period and require, besides the initial training, a continuous education approach meeting identified local needs. This theoretical and practical training should be challenging and of high quality to ensure procedural efficacy and safety. As per European guidelines, in our view, a minimum of two years of training in INR centres with a high level of activity seems necessary.

- **Minimum activity threshold**

COPIL proposes no consensus-based minimum threshold value. However, according to SFNR, a minimum of 40-50 cases per operator (average per operator observed in 2017), would be reasonable. According to the opinion of one COPIL member, it would be appropriate to adopt an activity over three of five years (to smooth any temporary gaps in activity) of at least 150 endocranial therapeutic endovascular cases over a five-year period, requalification every five years based on participation in a national registry and active participation in CME and meetings of learned societies aimed at neurovascular disease.

**Findings on team composition and professional training**

**MT team composition**

Based on all of the guidelines analysed and the opinions of the stakeholders, the composition of the medical and paramedical team required to carry out MT under optimal conditions is as follows:

- an MT interventionalist (*cf.* skills below);
- an anaesthetist with experience in caring for patients treated with interventional neuroradiology procedures;
- a medical radiographer;
- a state-qualified anaesthesia nurse (IADE);
- a surgical assistant (medical practitioner, nurse or medical radiographer).

**MT interventionalist skills**

MT interventionalists are required to have appropriate training and experience for the performance of neuroangiography and mechanical thrombectomy. The cognitive requirements consist of baseline training and qualifications, as well as ongoing professional education, which are essential for safe and efficient patient management.

The common foundation pertaining to clinical endpoints, training, MT regimens is based on a high level of skills:

- imaging and radioprotection expertise;
- percutaneous guidance and endovascular navigation expertise;
- expertise in clinical assessment and diagnostic and therapeutic patient management.

The technical skills for the MT procedure require:

- capacity to perform, conduct, and interpret standard diagnostic neuroradiology (CT scan, MRI, multimodal-imaging) for appropriate case selection;
- capacity to perform, conduct, and interpret MT procedures, as well as management skills for procedural complications;
- skills in the interdisciplinary management of ischaemic stroke patients with neurologists / neurosurgeons or other medical practitioners involved in stroke management in stroke centres;
- ongoing upgrading of diagnostic and therapeutic methods and skills required to carry out MT.

**Initial training**

Based on the international guidelines reviewed, training of interventional neuroradiologists and MT interventionalists should include theoretical and practical training in clinical neuroscience, diagnostic neuroradiology, and interventional neuroradiology.

In France, following the 2017 reform of post-graduate medical studies, the "Advanced interventional radiology" option offered in the post-graduate diploma in "radiology and medical imaging" currently solely accessible to radiology interns, aims to provide, over two years, training and expertise in "advanced, complex interventional radiology (IR) procedures", including MT. The theoretical and practical teaching for this option is carried out in "radiology departments with teams qualified to carry out complex IR procedures in respect of subspecialties", namely, stroke centre INR units, and makes it possible to acquire the skills mentioned above.

At the present time, no MT-specific specialised cross-disciplinary training (SCDT) is available enabling other medical specialties (neurologists, neurosurgeons, etc.) to be trained on carrying out MT within the framework of initial training.

In order to meet future care needs, HAS proposes extending MT training to other radiologists and to other medical specialties (neurologists, neurosurgeons and subsequently, if the need is not sufficiently covered, to interventional cardiologists), from the initial training stage by setting up specific SCDT.

**Continuous training**

The analysis of the literature demonstrated that, unlike initial training, there are a number of examples of continuous medical training enabling non-interventional neuroradiologists (neurologists, neurosurgeons, interventional radiologists, diagnostic neuroradiologists) to acquire the theoretical and practical skills required (clinical neuroscience, diagnostic neuroradiology and interventional neuroradiology) to perform INR, including MT. Note that the UK also provides such training open to cardiologists. The training durations vary from two to four years.

In France, an interuniversity diploma (DIU) in diagnostic and therapeutic neuroradiology is now available, making it possible to validate the two years of essential theoretical training to be able to practise comprehensive INR as a senior medical practitioner. This diploma is open to radiologists, neurosurgeons, and neurologists. On the other hand, no MT-specific continuous medical training is available.

Therefore, HAS proposes to create MT-specific continuous training, open to other radiologists and to other medical specialties (neurologists, neurosurgeons and subsequently, if the need is insufficiently covered, to interventional cardiologists).

**Minimum activity threshold for MT interventionalists**

Skills development is based on continuous professional development (CPD) and on a minimum activity threshold per interventionalist. However, no consensus has been reached on the value of this activity threshold.

**Minimum activity threshold for MT units**

- Failing literature of a sufficient level of evidence, HAS, on the opinion of experts, proposes an initial annual threshold of 60 cases. This threshold level should be assessed during the ramp-up phase and after five years, in the light of the number and distribution of cases.
- Moreover, this minimum activity threshold may also be modulated by the Ministry of Health or regional health boards based on specific scenarios (opening of a new unit, ramp-up of activity of a newly trained interventionalist, ultramarine context). Smoothing of the activity over a number of years should also be envisaged.

# 6. Assessment of the care pathway of the MT candidate patient

Management within a structured service, in liaison with a stroke centre, enables the optimal response to management challenges and expectations as regards optimal clinical patient outcome. In practice, this involves providing each patient with the optimum pathway, which may vary depending on the organisation, in order to ensure effective and safe care. In view of the findings of randomised controlled trials (3-7) (8) and the findings of the 2016 HAS technological assessment report pertaining to the benefit-risk aspects of MT (2), the major challenge consists of reorganising the system in order to provide early rt-PA initiation and make MT available for all eligible patients; furthermore, this involves reorganising the stroke service care networks dedicated to IV thrombolysis in order to include this new technology and maximise its benefits (57).

## 6.1 Data from the literature and French practice

### 6.1.1 MT candidate patient pathway

The analyses show that the efficacy of endovascular thrombectomy declines over time from the onset of symptoms, which requires the system to place an emphasis on timely assessment and treatment. Patients with suspected proximal arterial occlusion should be identified without delay, dispatched to the nearest suitable medical institution, diagnosed and treated with intravenous alteplase if eligible, and subsequently be assessed for endovascular treatment on-site or in a hospital with thrombectomy capability.

#### ► Patient pathway in France as per SFNR

According to the SNFR code of practice for mechanical thrombectomy practice requirements in France, the patient pathway includes a number of stages (12):

- "prehospital phase: patient call and dispatch to stroke centre or hospital linked to stroke centre via telemedicine;
- patient selection based on neurological examination and cerebrovascular imaging;
  - in the case of telemedicine, the clinical examination is conducted by the neurologist and the radiological interpretation is carried out by a radiologist with vascular neuroradiology expertise;
- MT indication: neurological and neuroradiological consultation on-site or via remote assessment;
- contact of anaesthetist;
- dispatch to stroke centre for MT;
- patient admission to stroke centre - thrombectomy procedure;
- return to specialised ward in stroke centre or to neurointensive care unit".

#### ► Recommendations of the Department of Health Coverdell Stroke Program and the *American Heart Association / American Stroke Association* (AHA/ASA)

These recommendations drafted jointly by the Department of Health of the State of New York, the *American Heart Association* (AHA), and the *American Stroke Association* (ASA) are aimed at enhancing systems of care for stroke with large vessel occlusion (44). They are based on six themes:

- emergency medical services capacity (an overburdened emergency medical services system, funding inadequacies, long-distance transport burden, and training feasibility);
- use of validated screening tools to diagnose large vessel occlusion;
- clear definitions of facility capability (primary stroke centre versus comprehensive stroke centre, the role of endovascular-capable centres);
- clear guidelines for prehospital triage and interfacility transport;
- data capture and feedback tools;

- competition because of costs, resources, and threats to interfacility collaboration.

### ► Prehospital triage and tools: A-level recommendations

| **A1: high impact, high feasibility** |
|---|
| Online medical control: to assist with the decision-making process concerning transport to a PSC, CSC, or endovascular-capable centre |
| **A2: high impact, moderate feasibility** |
| Regional transportation strategy: based on prehospital diagnosis to the most appropriate centre |
| Standardised emergency medical services checklist: for assessment of a stroke patient, inclusive of information, such as last known well, family/witness contact information, contraindications to thrombolysis, etc. |
| Quality metrics: to assess prehospital performance |
| Standardised prehospital stroke screening tool: to assess for large vessel occlusion; determine the most appropriate screening and standardise its use by region (perhaps statewide).<br>Feedback to emergency medical services for performance improvement |
| **A3: high impact, low feasibility** |
| Smartphone application algorithm: to assist with the decision-making process for transportation |

### ► Interfacility transfer: A-level recommendations

| **A1: high impact, high feasibility** |
|---|
| Standardised transfer process: includes automatic activation of an interfacility transfer unit and pre-established packaging list for patient transfer |
| Established transfer timing goals: set expectations for transfer timing goals between agencies and hospitals; clearly delineate an emergency medical services unit's capacity for transfer, including upgrading a unit capable of transfer if necessary |
| Regionalised stroke systems: establish stroke systems that complement preestablished patterns of patient transfer within facilities in the region building on trauma and STEMI (ST-segment elevation myocardial infarction) models |
| Performance metrics: to assess performance at stroke centres, including door-in-door-out and timing goals for emergency medical services transfer |
| Image sharing capabilities: establish capabilities between facilities |
| **A2: high impact, moderate feasibility** |
| Provider (emergency medical services and hospital) education: on the transfer process, including standardisation of content and as a means of peer-to-peer support |
| *Stroke Tool Box*: that lists necessary information and equipment for the safe and expeditious transfer of patients between facilities |
| **A3: high impact, low feasibility** |
| Interfacility telemedicine: to assist with the transfer decision-making process |
| Feedback system: to institutions and emergency medical services for performance improvement |

### ► Society of Vascular and Interventional Neurology (SVIN) chain of survival

In the United States, the Society of Vascular and Interventional Neurology (SVIN) has issued guidelines for effective application of endovascular acute stroke therapy using the "8D" approach in the stroke chain of survival approved by the *American Heart Association / American Stroke Association* (AHA/ASA) from 2013 (38).

Developed by the *American Heart Association / American stroke Association* (58), the chain of survival is a series of actions which, when carried out together, give the patient better chances of survival.

**Table 4. Stroke chain of survival as per 2013 AHA/ASA guidelines (58).**

| ***8 D approach*** | |
|---|---|
| *Detection* | Patient or bystander recognition of stroke signs and symptoms |
| *Dispatch*: 911 medical response service[16] | Immediate activation of 9-1-1 and priority EMS dispatch |
| *Delivery* | Prompt triage and transport to most appropriate stroke hospital and prehospital notification |
| *Door*: admission | Immediate ED evaluation ideally by pre-notified neurologists; if evaluation done at an outside hospital, direct transport to brain imaging or angiography suite or stroke intervention lab is encouraged |
| *Data*: neurovascular service activation, clinical assessment, brain and vascular imaging, pathological tests | Prompt ED evaluation, stroke team activation, laboratory studies and brain imaging |
| *Decision* | Diagnosis and determination of most appropriate therapy; discussion with patient and family |
| *Drug* | Administration of appropriate drugs or other interventions |
| *Disposition* | Timely admission to stroke unit or intensive care unit, or transfer |

### Recommendations for Detection and Dispatch

Public health campaigns regarding stroke symptoms, their emergency nature (necessitating contact and expeditious arrival of mobile emergency services) and the availability of time-sensitive treatments are needed.

### Recommendations for Delivery

Similar to the approach adopted by the *American Heart Association* for ST-segment elevation myocardial infraction (STEMI), a multisociety collaborative approach should be created to drive development of LVO AIS systems of care. A reasonable model would be to consider a triage system based upon the severity and duration of symptoms. As such, all patients within the time window for IV thrombolysis might best be delivered to the nearest stroke centre unless the added transport time to an endovascular-capable hospital is less than 30 min, whereas all patients ineligible for IV thrombolysis due to symptom duration might best be triaged directly to the nearest endovascular-capable hospital.

### Door, Data, Decision, Drug and Disposition

Door, data, decision, drug and disposition encompass the critical management steps that

begin once the AIS patient arrives at the receiving hospital. These include immediate emergency department (ED) triage to a high-acuity area, prompt ED evaluation, 24/7 stroke team activation,

[16] Equivalent to the SAMU 15 advice line in France.

laboratory studies and advanced brain imaging, diagnosis and determination of the most appropriate therapy, administration of appropriate drugs or other interventions (rt-AP, and now mechanical endovascular reperfusion), and timely admission to a stroke unit or intensive care unit.

#### Posthospitalisation care coordination

Many LVO AIS patients currently treated at high volume stroke centres are patients

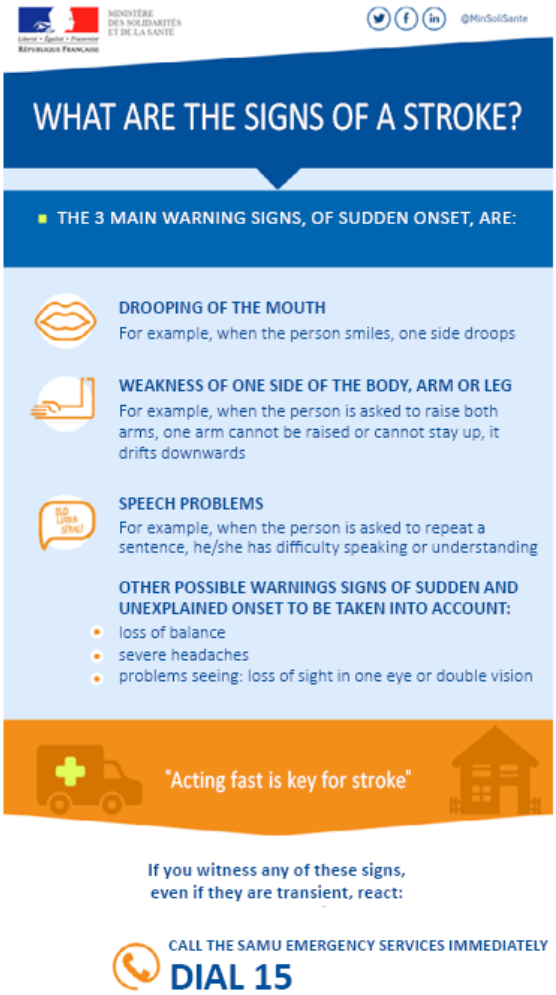
transferred from outside hospitals. This system will likely evolve in the future towards direct transport of the suspected AIS patient to a CSC. In either scenario, CSCs need a monitored system that ensures adequate communication with the patient's discharge facility (e.g., to an acute rehabilitation facility) and the patient's local physicians to coordinate long-term care (e.g., acute rehabilitation needs, treatment plan for secondary prevention of stroke).

Centres would be best served by cooperative protocols or transfer agreements to transition patients earlier to rehabilitation. Stroke centres should ensure that acute in-patient rehabilitation facilities that receive their patients be adequately resourced and trained in standardised outcome scales. In addition, stroke centres should encourage acute in-patient rehabilitation facilities to obtain appropriate certifications such as TJC stroke rehabilitation certification or Commission for Accreditation of Rehabilitation Facilities (CARF) certification.

### 6.1.2 Detection: information and awareness

Note: the description of detection procedures (15 emergency advice line, call handling, emergency medical services, etc.), provided in this report, is based on the current organisation and regulations. This description will be subject to change in the event of modifications of the organisation and regulations of detection procedures.

In order for stroke patients to receive care in a timely manner, stroke symptoms must be known to the general population, and more particularly by patients presenting with risk factors or previous history of vascular disease, as well their relatives. In France, information campaigns targeting the general public have been conducted by the Ministry of Health.


Stroke management also requires that the initial prehospital and hospital care services be effective and, for this, awareness should be raised among professionals.

### ► HAS guidelines for the early management of stroke (2009)

The HAS best practice guidelines (15) for the early management of stroke (detection, prehospital phase, initial hospital phase, thrombolysis indications) published in 2009, highlighted the importance of the roles of the "centres 15" response centres and the primary care physician.

### Centre 15 response centre

Activation of the alert by calling an emergency number, call handling and urgent dispatch to an identified hospital are critical for expeditious patient care.

In France, the prehospital medical processing concept applied at the SAMU-Centre 15 advice line hinges on two points.

Firstly, call handling[17] enables the triage physician to assess the clinical context and adapt the dispatch of resources (medical, first aid, ambulances) to the patient. Following the evaluation conducted and forwarded by the teams on-site, he/she optimises the transfer of the patient to suitable facilities and defines the mode of transportation, which may or may not be medicalised. He/she contacts the hospital teams to present the patient, ascertain accommodation capacity and thereby optimise preparation for the patient's admission.

[17] CRRA: call taking and handling centre - or SAMU Centre 15.

Medicalised transport represents the other aspect of care for patients who need it. The triage phase should be based on a directory of stroke resources. By listing all care provision options in terms of technical platforms, skills and local organisations in a very accurate manner, it serves as a key tool for SAMU-Centre 15 triage physician to optimise the triage process for patients in coordination with specialised teams. Some local organisations providing patient care allow for the option to use private medical care providers coordinated by the SAMU-Centre 15.

### Role of the primary care physician

In France, since 2005, all patients must designate a primary care physician. Ninety-five percent of these are general practitioners. The role of the primary care physician is particularly to provide a primary level of care, guide the patient in the care pathway, contribute to health promotion, and summarise information provided by different care providers. As such, a general practitioner attends to 2000 patients on average per year. He/she provides care for 18 stroke survivors and will see at least one new case of stroke every three months. The primary care physician is therefore one of the cornerstones of patient information on optimal acute stroke management. He/she must provide information to at-risk patients (previous history of vascular disease, arterial hypertension (AH), diabetes, arterial disease of the lower limbs, etc.), as well as to their relatives, on the main stroke symptoms. He/she should explain the importance of recording the time of onset of symptoms of stroke (professional agreement). In the event of the onset of symptoms, he/she should recommend calling the SAMU-Centre 15 advice line immediately even before calling his/her practice.

In the event of patient presenting with signs suggestive of stroke calling the practice or the practice call centre directly, the primary care physician should forward the call to the SAMU-Centre 15 advice line and at best remain on the line in order to set up a three-way conference call (caller, primary care physician, SAMU-Centre 15 triage physician) (15).

According to these HAS best practice guidelines, information in general public campaigns on early management of stroke should cover the following three main areas:

- identifying symptoms indicating a potential stroke;
- the existence of emergency care and treatments (admission to stroke centre and thrombolysis);
- the need for emergency aid as a matter of priority by contacting the centre 15 advice line.

The key messages to be broadcast to professionals providing stroke management services include the need to:

- consider any sudden, transient or sustained neurological deficit as an absolute emergency;
- record the precise time of the onset of symptoms;
- be aware of the effectiveness of the care provided in stroke centres;
- be aware of specific therapies for stroke (15).

### ► Systematic review by Daubail *et al.* (2016)

In 2016, Daubail *et al*. of the University of Dijon (29) analysed the clinical findings, as well as the organisational aspects of the latest endovascular trials and recent meta-analyses including almost 15% of patients treated with rt-PTA. The organisational aspects analysed concern the creation of a system including triage of patients with suspected stroke in primary stroke centres and their transport to comprehensive stroke centres as quickly as possible. In order to deal with the possibility of the exclusion of patients whose symptoms may not have been detected in the prehospital process, the authors are of the view that patients and their entourage must be aware of the first symptoms of stroke using the FAST test and then the interhospital organisation must be able to deliver rt-PA and MR directly in a tertiary comprehensive centre or via telestroke for rt-PA perfusion.

### ► *Royal College of Physicians* guidelines: "*National clinical guideline for stroke*" (2016)

The 2016 *Royal College of Physicians* guidelines state that it is vital that members of the public and healthcare professionals (e.g. primary care team members, telephone advice line staff, para-

medics) can recognise stroke as early as possible to facilitate an appropriate emergency response. Measures taken by clinicians outside hospital (such as reduced time at the scene) can reduce the overall time to treatment, and thereby improve the prospects for the patient to respond to treatments.

The training of primary care teams, other healthcare personnel and the general public in the recognition of the signs of possible stroke using the FAST involves an ongoing public health commitment requiring multiple approaches. Patients in groups at high risk of stroke (e.g. older people with diabetes, hypertension or atrial fibrillation) and their family and/or carers should have training in the FAST test as part of their disease education (36).

#### ► Cohort study by Sheppard *et al.* (2015)

The aim of this study was to examine the association between prehospital assessments and prenotification (specifically, the relationship between time of CT request, time of first contact with stroke team, recording of symptom onset time, stroke recognition using the FAST (*Face Arm Speech Time*) test and sending of a hospital prealert) by emergency medical service staff on the subsequent acute stroke care pathway (59).

One hundred and fifty-one patients transferred to hospital by ambulance were analysed in this study. The study highlighted, after adjustment for confounding, the importance of the following three factors:

- hospital prealerting (HR 0.26; 95% CI [0.18 to 0.38]);
- accurate stroke recognition (HR 0.54; 95% CI [0.37 to 0.80]);
- recording symptom onset time (HR 0.73; 95% CI [0.52 to 1.03]).

Those not recognised with stroke in a prehospital setting exhibited a high risk of being excluded from the comprehensive treatment.

### 6.1.3 Prehospital phase

#### ► Patient assessment

As early management is critical in cases of stroke, it is important that healthcare professionals are capable of detecting potential stroke with a few simple tools. To detect stroke, during the prehospital phase, professionals should be provided with simple tools suitable for timely use. A distinction is made between diagnostic tools (Cincinnati scale, FAST scale, Los Angeles scale, ROSIER scale) and stroke severity scales such as NIHSS (*National Institutes of Health Stroke Scale*).

#### HAS guidelines for the early management of stroke (2009)

HAS best practice guidelines (15) for the early management of stroke recommend using a limited number of stroke assessment scales so as to standardise stroke care:

- the FAST scale (or its French equivalent) should be used as a diagnostic tool for paramedics and first responders who should be trained accordingly (professional agreement);
- all emergency physicians should be capable of using the NIHSS scale (*National Institutes of Health Stroke Scale*) and assessing stroke severity (professional agreement).

#### *American Heart Association* / *American Stroke Association* (AHA/ASA) guidelines (2018)

According to the 2018 joint *American Heart Association* / *American Stroke Association* (AHA/ASA) guidelines, EMS leaders, in coordination with local, regional, and state agencies and in consultation with medical authorities and local experts, should develop triage paradigms and protocols to ensure that patients with a known or suspected stroke are rapidly identified and assessed by use of a validated and standardised instrument for stroke screening, such as the FAST (face, arm, speech test) scale, Los Angeles Prehospital Stroke Screen, or Cincinnati Prehospital Stroke Scale (class I, level of evidence B-NR).

### ► Call handling on SAMU-Centre 15 advice line

In France, according to the code of practice of MT, the role of EMS call handling and prehospital patient dispatch, which is already critical in stroke services, should be reinforced further in thrombectomy management (12).

The organisation of EMS services needs to be assessed in terms of two aspects:

- influence on times to admission to hospital, but also intrahospital transfer times, through more expeditious access to specialised expertise and imaging;
- definition of clinical criteria justifying the presence of a medical practitioner for clinical assessment and medical supervision during transportation to hospital.

#### HAS guidelines for the early management of stroke (2009)

The HAS best practice guidelines (15) for the early management of stroke recommend the following points:

- the initial call by a patient or his/her entourage for suspected stroke should be handled by SAMU-Centre 15 call handling centres (professional agreement);
- standardised targeted questionnaires should be used for the telephone assessment of patients presenting with suspected stroke and to aid decision-making by the triage physician (professional agreement);
- all cases of medical call handling of a patient with suspected stroke or TIA shall include a call to the medical practitioner at the nearest stroke centre. Triage is decided in concert between the triage physician and the stroke centre physician (professional agreement).

### ► Patient transfer

Interfacility transfer raises an important question: should emergency medical services transporting an acute stroke patient with a symptom onset < 6 hours go straight to a comprehensive stroke centre at a greater distance, bypassing nearer facilities (a primary stroke centre or a healthcare facility with no stroke centre on-site but with an emergency department)?

If the transport times between the comprehensive stroke centre and the primary stroke centre/emergency department are similar, then the likelihood of obtaining a good outcome is increased by dispatching the patient directly to the comprehensive stroke centre, if the comprehensive stroke centre has favourable treatment time intervals, however.

If the comprehensive stroke centre is much further away than the primary stroke centre, then alteplase should be accompanied in parallel with steps to initiate immediate transfer to the comprehensive stroke centre. The need to assess and treat the patient at the comprehensive stroke centre should be evaluated in the light of the current capability of these centres to handle the expected patient caseload.

#### HAS guidelines for the early management of stroke (2009)

The HAS best practice guidelines (15) for the early management of stroke (detection, prehospital phase, initial hospital phase, thrombolysis indications) published in 2009, state that the dispatch of a mobile medical unit should not delay the care of a suspected stroke patient. This dispatch is necessary in cases of consciousness disorders, respiratory distress or haemodynamic instability.

Call handling centres should select the most expeditious mode of transportation to dispatch the patient (professional agreement).

In cases of medicalised transport, it is recommended to take blood samples enabling pathological profiling, pending onboard pathological assessment (professional agreement).

### *American Heart Association* / *American Stroke Association* (AHA/ASA) guidelines (2018)

According to these guidelines, patients with a positive stroke screen and/or a strong suspicion of stroke should be transported rapidly to the closest healthcare facilities that can capably administer IV alteplase (**class I, level of evidence B-NR**).

Different services within a hospital that may be transferring patients through a continuum of care, as well as different hospitals that may be transferring patients to other facilities, should establish hand-off and transfer protocols and procedures that ensure safe and efficient patient care within and between facilities. Protocols for interhospital transfer of patients should be established and approved beforehand so that efficient patient transfers can be accomplished at all hours of the day and night (**class I (strong), level of evidence C-EO (expert opinion)**).

When several IV alteplase–capable hospital options exist within a defined geographic region, the benefit of bypassing the closest to bring the patient to one that offers a higher level of stroke care, including mechanical thrombectomy, is uncertain. Further research is needed (**class IIb, level of evidence B-NR**) (35).

### *European recommendations on organisation of interventional care in acute stroke* (EROICAS) (2016)

- Patients should undergo diagnostic imaging as fast as possible and receive IV rtPA as fast as possible when indicated (**quality of evidence: high, strength of recommendation: strong**).
- In a situation with equidistant hospitals, direct transfer of selected patients likely to have LVO to a hospital offering EVT should be considered.
- Hospitals without interventional services for stroke therapy should implement policies for transfer of patients to EVT sites, consistent with a network as recommended for EMS organisation.
- Referring hospitals should have an established IV thrombolysis service and be able to initiate treatment in appropriate cases within a time-frame sufficient to allow transfer, clinical and imaging assessment, and procedural initiation at the interventional centre within a maximum of six hours after symptom onset (or "*last known well time"*). This means that IV rtPA onset to treatment times for potential EVT cases will in general be considerably shorter than the maximum time window permitted for IV rtPA therapy alone (**quality of evidence: moderate, strength of recommendation: strong**) (37).

### Review of the implications of endovascular therapy for the organisation of stroke systems of care in North America

In this review which presents North American registry data on the implications of endovascular therapy for the organisation of systems of care, the authors report that 25% of stroke patients present within 3 hours after the onset of symptoms, and 36% within 8 hours. Therefore, extending the bypass criterion from 0 to 3 hours up to 6 to 12 hours could potentially increase the number of EMS bypass cases by more than 50%, with increased case volume at primary stroke centres and comprehensive stroke centres. If bypass is extended to primary stroke centres, such that these patients are taken only to comprehensive stroke centres, the increase in case volume at the comprehensive stroke centres could be substantial and potentially detrimental. To mitigate these effects, it is reasonable to exclude from thrombectomy-based triage patients with preexisting disability who are unlikely to benefit, such as those with modified prestroke Rankin score of > 2. Certain communities may benefit from alternative strategies, such as mobile stroke units, or use of telemedicine-enabled vascular neurology consultation into the EMS vehicle.

Moreover, the authors of the review recommend that public health agencies, such as

departments of public health and provincial and regional health authorities, establish regulations about stroke patient transfer that are appropriate for the resources available in their local settings with a deliberate effort to encourage access to acute stroke-ready hospitals and primary stroke centres for all citizens and strategically placed comprehensive stroke centres to leverage this network of care.

### ► Organisation of interfacility transfers based on the "*Drip-and-Ship*" *versus* "*Mothership*" models

#### Systematic review by Evans *et al.* (2017)

According to this practical guide, MT needs meticulous organisation and robust, well-audited care pathways to enable safe and rapid transfer. The two potential models for providing thrombectomy can be described as "*drip and ship*" (initial transfer to a local stroke centre for diagnosis and intravenous thrombolysis, followed by rapid transfer to a specialist thrombectomy centre) and "*mothership"* (transfer immediately to a specialist comprehensive stroke centre able to undertake thrombectomy and other required neuroscience support services). The optimal model will vary according to local geography including population density, transport infrastructure and distance from specialist centres able to deliver the treatment safely and effectively. "*Drip and ship"* might be the more appropriate solution for more remote areas, while a "*mothership*" model might be a good solution for urban city populations (32).

#### Systematic review by Daubail *et al.* (2016)

According to this review, every hospital performing rt-PA must be able to detect large vessel occlusion by CT angiography (CTA). Depending on the imaging findings, the patient will then be managed in a dedicated stroke unit using rt-PA alone or transferred to a comprehensive stroke centre offering endovascular therapy. In urban regions with good coverage by comprehensive stroke centres, patients with high NIHSS scores (>10) who have a high probability of large vessel occlusions should primarily be directed to centres that provide endovascular neuro-radiology services (29).

### ► Retrospective study by Gershenfeld *et al*. (2017)

The aim of this study was to compare the impact of transfer on three-month neurological recovery (mRankin 0-2) between patients transferred after IVT (*drip and ship*) to those treated on-site (*mothership*).

One hundred and fifty-nine patients were treated by interventional radiological therapy (IRT) at Fondation Rothschild (FOR) after IVT: including 100 after transfer from the Saint-Antoine / Tenon (SAT) hospitals and 59 directly on-site at FOR. The patients were more severe in the FOR group: median NIHSS of 17 *vs* 15 (p 0.025), median ASPECTS-DWI of 7 *vs* 7.5 (p 0.046). The process times were shorter in the FOR group compared to the SAT group, with an interval between symptom onset and treatment onset of: 135 *vs* 150 min for recanalisation (IVT), 189 *vs* 248 min for onset to puncture and 240 *vs* 297 min for onset to reperfusion. The reperfusion score (TICI 2B-3) was similar in both groups (FOR 80%, SAT 84%), and the same applied for PH2 haemorrhagic transformations (FOR and SAT 8%). The three-month mRankin 0-2 score was similar: FOR 52%, SAT 61% (p 0.26), including after adjusting for the NIHSS and ASPECTS scores (p 0.82).

The data show that patient transfer for IRT is associated with a significant prolongation of the IVT-to-puncture time by 45 minutes ("*drip-and-ship"* 48 *vs* "*mothership*" 93 min, p<0.001). Nevertheless, there was no significant difference on the three-month modified Rankin score (mRankin) of 0-2 between the two groups. This is explained, according to the authors, by the transfer speed, made possible by the geographic proximity (< 5 km) of the two centres and good upstream stroke centre and IRT centre coordination. A superior benefit of combined on-site care might be observed by reducing the median IVT-puncture time in the "*mothership" group*, which is 48 minutes.

According to the authors, this real-life study demonstrates that patients transferred for IRT (*drip-and-ship*) treated within six hours also benefit from combined care, with no significant difference with those treated on-site (*mothership*) (60).

### ► Regional interfacility transfer procedures and protocols in France

The current regional organisation of early stroke management in France requires the establishment of interfacility transfer protocols to enable patients admitted for IV thrombolysis to access the INR

technical platform, if MT is indicated. The following data have been collected from the regional health boards.

In the **Hauts de France** region, CHU Amiens has made interfacility transfer protocols available for all general hospitals (CHGs) from the former Picardy region.

In the **Occitanie** region, the institutions have signed interfacility agreements for the implementation and use of telestroke consultation or telestroke assessment. Professionals have also reached an agreement on 15 advice line call handling criteria to direct the patient straight to the regional comprehensive stroke centre, bypassing the primary stroke centre.

As regards the **Burgundy-Franche-Comté** region, the remote selection protocol of patients eligible for MT in Burgundy is based on a strict imaging protocol, for the assessment of the parenchyma and all extra- and intracranial brain vessels in each of the 19 general hospitals in the network, by electronic image transfer and remote consultation of the patient by the neurovascular surgeon who subsequently reviews the clinical and radiological file with the INR. Patients are transferred to Dijon generally in one of the region's three helicopters. For Franche-Comté, the RUN network only has one neurosurgery department and one comprehensive stroke centre (neurosurgery and interventional neuroradiology) for neurovascular disease, at CHRU Besançon. The RUN network has developed telemedicine systems enabling the transfer of skills and know-how for each local service. Once emergency diagnoses have been established via telemedicine systems, a nurse tracks the patient care pathway, until the patients have been discharged from short-stay hospital care. A logic diagram describes and pre-empts the initial patient pathway, whether he/she is admitted directly into the INR-capable centre or into a remote centre without such capability.

In the **Centre-Val-de-Loire** regions, patient transfer agreements between CHU Tours and the other institutions in the region to accommodate patients requiring thrombolysis or MT have been put in place. Priority access for these patients to the Tours stroke centre reduces access for patients not subject to a revascularisation alert. The patient transfer procedure from Bourge to Tours hospital in the event of MT being indicated is currently at the drafting stage.

In the **Auvergne-Rhône-Alpes** region, the protocol within the framework of the Renau for patient selection and transfers is operational.

In the **Nouvelle-Aquitaine, Normandy and Indian Ocean regions**, interfacility transfer protocols are currently being drafted. However, difficulties have been highlighted by the comprehensive stroke centres in the Nouvelle-Aquitaine region when they wish to redirect patients having undergone MT to their original stroke centre for their subsequent care.

On the other hand, in **Brittany and in the Grand-Est** region, there are no interfacility transfer protocols; calls are handled on a case-by-case basis by the departmental emergency medical services triage physician in Brittany. Secondary transfers represent one of the factors limiting access to MT, which gives rise to inequalities between localities due to organisational and financial difficulties.

In the **Ile-de-France** region, a framework document for the organisation of MT has been distributed to all EDs.

### 6.1.4 Telestroke in the MT candidate patient care pathway

Telestroke is incorporated in this care pathway and helps improve access to the best care without delay by promoting access to expertise. The telestroke principle is based on the ability to provide neurovascular expertise to healthcare institutions where it is not available, via the transmission by the sender institution of very high-quality images to the 24/7 on-call neurologist and radiologist on a different recipient site, generally the university hospital (CHU). In cases of suspected stroke, the neurologist may thus decide whether or not to carry out a thrombolysis and/or mechanical thrombectomy procedure on the basis of the transmission of the MRI findings.

In France, the very first trials took place in September 2001. It is estimated that two-thirds of the territory are currently covered by telestroke schemes. Telestroke was "industrialised" ten years

later in three pilot regions: Franche-Comté, Burgundy, and Nord-Pas-de-Calais. The scheme is currently being rolled out led by the regional health boards (ARS) and following on from the 2010-2014 Stroke Plan and the framing of telemedicine through article 78 of the "Hospital, patients, health and territory" law of 2009 and the decree of 2010 (61).

According to a French review in 2017, a number of studies have demonstrated the safety and efficacy of telemedicine by enabling a reduction in times-to-treatment and an increase in the number of intravenous thrombolysis cases while offering an equivalent functional prognosis to patients treated more conventionally. This scheme is particularly useful in very extensive regions with a limited number of NICU units (62).

Neurovascular expertise has been reinforced, the number of institutions with telestroke capability increased from 112 in 2015 to 200 in 2017:

- 134 institutions were requesting facilities (institutions with the option of requesting expertise via the telestroke scheme);
- 48 institutions were requested facilities (institutions solely requested for expertise);
- 18 institutions were requesting and requested facilities.

This scheme enables neurovascular expertise to be shared with institutions where it is not available. In many localities, it enables access to this expertise within shorter time-frames (48).

#### ► *American Heart Association / American Stroke Association* (AHA/ASA) guidelines (2018)

For sites without in-house imaging interpretation expertise, teleradiology systems approved by the US *Food and Drug Administration* (FDA) are recommended for timely review of brain imaging in patients with suspected acute stroke (**class I, level of evidence A**).

Because of the limited distribution and availability of neurological, neurosurgical, and radiological expertise, the use of telemedicine/telestroke resources and systems can be beneficial and should be supported by healthcare institutions, governments, payers, and vendors as one method to ensure adequate 24/7 coverage and care of acute stroke patients in a variety of settings (**class IIa, level of evidence C-EO, expert opinion**).

Telestroke networks may be reasonable for triaging patients with AIS who may be eligible for inter-facility transfer in order to be considered for acute mechanical thrombectomy (**class IIb, level of evidence B-NR**).

#### ► *Royal College of Physicians "National clinical guideline for stroke"* guidelines (2016)

The *Royal College of physicians*, in these guidelines on the role of MT in the IS management strategy, states that telemedicine is used in some centres to support decision-making in hyperacute stroke because of significant practical or geographical obstacles. However, it is reported that observational evidence suggests that telemedicine is

associated with more protocol violations and longer treatment times (36).

### 6.1.5 Regional feedback on telemedicine in France: data collected from regional health boards

#### ► Ile-de-France

Telemedicine is organised for the transfer of images between all EDs, stroke centres, neurosurgery and INR departments; telemedicine with video consultation is organised in the metropolitan area between EDs and stroke centres.

Telemedicine with image sharing is used essentially in the context of MT. There are many opinions on image transfer, opinions on video consultation are poor, due to their time-consuming aspect for emergency physicians and neurologists and the practical difficulties in an emergency setting.

## ► Hauts-de-France

### In "former NPDC" region

The telestroke scheme was launched in June 2011 in two healthcare localities (Artois-Douaisis and Hainaut-Cambrésis, thereby forming the "HAINAUT-ARTOIS" (H-A) telestroke scheme, currently linking seven hospitals including one university hospital, four stroke centres, and two thrombolysis units. This scheme allows two million inhabitants to benefit from this new care provision. From 2015, the other healthcare localities of the former NPDC region became involved in the same project, thereby creating new thrombolysis units linked with four stroke centres. The medical regimens and procedures for the management of stroke are pooled and shared.

The different telestroke schemes have been framed by the regional health board and guided by stroke service facilitators so as to structure medical and paramedical organisations (building the medical projects prior to the implementation of telemedicine), and guide roll-outs. At the present time, the schemes in place enable remote neurological and radiological assessment. In the event of indications for referral to CHRU Lille, the requested facility neurologist reaches out to the CHRU neurovascular team. If the request is approved, the transport will be medicalised.

After six years of setting up this scheme: referrals are increasing significantly, it has been necessary to increase the capacity of the CHRU Lille stroke centre to meet the strong demand. For this reason, in parallel, transport has been impacted in the same way.

The CHRU referral as described above is only in place for the Hainaut and Artois localities. This scheme should shortly be extended to other localities in the NPDC region, once the capacity at CHRU Lille has been readjusted and the neurological medical staffing reinforced.

### In "former Picardy" region

The telestroke scheme was launched in 2007 at Abbeville hospital in consultation with CHU Amiens. In 2016, a second telestroke scheme was created between Soissons hospital (requested facility) and Château-Thierry hospital (requesting facility). A third telestroke scheme was set up in 2016, running in alternation 15 days per month, between Beauvais hospital and CHU Amiens, due to neurological medical staff shortages in this third facility.

Transport is also impacted (increased), due to early post-thrombolysis and post-thrombectomy medicalised transport.

The technical telemedicine system differs from that of the former NPDC region but also enables remote neurological assessment conducted by the requested neurologists at CHU Amiens or Soissons hospital.

The medical and medicinal product regimens have all been set out in writing by CHU Amiens and are shared by all general hospitals, whether linked by telemedicine or not.

For the thrombectomy activity in the Aisne department, and more specifically the southern part of the Aisne department, patients are preferentially directed to CHRU Reims, without a prior remote assessment.

## ► Occitanie

The implementation of telemedicine schemes in the Occitanie region for stroke management addressed the needs and expectations of professionals in order to improve and facilitate referral to neurological and/or neuroradiological expertise. Feedback from professionals has been positive and indicates a good uptake/use of these tools.

The issue of stroke management is the subject of annual or twice-yearly multidisciplinary meetings in this region (neurologists, emergency physicians, neuroradiologists, etc.). Some of these meetings have discussed and continue to discuss access to mechanical thrombectomy (MT), which is a therapy recognised very recently by learned societies in stroke management. As such, initial conditions for the organisation of and access to MT have been defined collectively. Furthermore, it im-

portant to point out that the regional health board and professionals are mindful of the development of MT which needs to be carried out in parallel with continuity of timely access to the nearest stroke centre or an orphan facility with telestroke capability and continued growth in the rate of referral to thrombolysis.

### ► Nouvelle-Aquitaine

In the Nouvelle-Aquitaine region, a ramp-up in cases using telestroke (remote assessment and tele-thrombolysis) has been observed, although the activity remains generally low (378 cases for 116 tele-thrombolysis cases). Nevertheless, a noteworthy improvement in the quality of care has been observed, particularly for patients from healthcare institutions with no neurologist. Furthermore, telestroke development facilitates interfacility cooperation and links.

As regards MT, the decision to carry out MT is made jointly by a neurologist and an interventional neuroradiologist from one of the three comprehensive stroke centres (CHU Bordeaux, Limoges, Poitiers), at the request of the emergency physician initially attending to the patient. The patient pathway (via stroke centre or direct access to MT in a comprehensive stroke centre) is dependent on the patient's neurological status and the emergency imaging findings.

### ► Burgundy-Franche-Comté

#### Former Burgundy region

- The combined care and telestroke network makes it possible to meet the thrombolysis needs of stroke patients in this region; this close-knit territorial network, with 19 hospitals, has proven to be efficient not only in quantitative terms, but also in terms of quality and safety, as tele-thrombolysis patients had the same recovery rates as patients undergoing thrombolysis at the CHU Dijon NICU unit, with no more complications;
- MT screening has benefited from the experience of the stroke and TLM network in place since 2003, and in particular from the expertise of the four-member INR team in Dijon.

The Burgundy model accounts for delays and the level of experience of the requesting general hospital and therefore considers two types of scenarios (29):

- either the patient is transferred immediately to CHU Dijon to receive thrombolysis and MT after the indication has been established by the paired neurologist and neuroradiologist in Dijon;
- or the patient has the time to undergo tele-thrombolysis on-site, followed by a secondary transfer to the CHU Dijon INR unit. The patient will be monitored for at least 48 hours, either at the NICU unit, or in neurotrauma intensive care.

For stroke management with direct oral anticoagulants (DOACs), Dijon is equipped with a haematopathology laboratory with expertise in the field of DOAC assay and reversal, with a regional protocol.

#### Former Franche-Comté region

The former Franche-Comté region is a pilot telestroke region in France, with the first trials recorded in 2002. The telemedicine scheme in place in Franche-Comté for a number of years is one of the critical factors for accessibility to expertise, whether the expertise is neurological, neuroradiological or neurosurgical. It is based on a regional network, the cornerstone of which is the CHU Besançon comprehensive stroke centre which ultimately provides 24/7 expertise for all the institutions in the region. The principle of equity guarantees that each citizen can access emergency expertise enabling superior clinico-radiological diagnosis and a superior therapeutic indication, including the indication of complex therapies such as thrombolysis, thrombectomy or craniectomy.

In Franche-Comté, all centres receiving stroke patients (eight, including the comprehensive stroke centre) are telestroke-capable. The pooling of the telemedicine (TLM) scheme for all neurological emergencies has enabled more than 2000 TLM cases annually, including 40% telestroke cases (around 200 thrombolysis cases/year including almost one-third via the tele-thrombolysis scheme,

around 100 thrombectomy cases in 2016 including around 40% with decision-making assistance via tele-thrombectomy).

### ► Centre-Val-de-Loire

In the Centre-Val-de-Loire region, the telestroke scheme has been rolled out to two facilities: Montargis hospital (since February 2016, around twenty procedures, including eight in 2017), and Châteauroux hospital (in 2017, 14 patients transferred to CHU Tours following thrombolysis or for MT). It was planned to extend the scheme to two further facilities by the end of 2017.

The benefit of this scheme has been confirmed in terms of:

- reduction in times to treatment;
- organisational structure as the scheme requires a shared discussion between emergency physicians and neurologists from various institutions.

Two types of difficulties are encountered:

- 24/7 access to all the links in the chain:
  - Montargis MRI only accessible during working hours,
  - regional outflows connected with a contingency problem at the CHU (hesitancy of non-vascular neurologists at the CHU to take on this task 24/7 to guarantee 24/7 access);
- the sustainability of the scheme following emergency physician team changes in small hospitals subject to a high turnover of medical staff and use of locum emergency physicians. There is a risk of the investment in terms of training and knowledge of the procedures developed in common being lost.

### ► Auvergne-Rhône-Alpes

En Auvergne-Rhône-Alpes, telestroke has already been rolled out by the neurological services *via* Renau.

Communication takes place at three frequencies between the CHU Grenoble comprehensive stroke centre (with thrombectomy), the Chambéry hospital primary stroke centre (without thrombectomy) and the telestroke unit at Bourg-Saint-Maurice located between the two, but more dependent on Chambéry hospital.

### ► Brittany

In Brittany, telestroke has been in place between Lannion and St-Brieuc hospitals and between Morlaix hospital and CHU Brest since 2016 for the areas at the greatest distance from the stroke centre in terms of access time. It is carried out with a fixed remote consultation station in the emergency department, which enables secure transmission of imaging, laboratory findings, the patient record, as well as a remote video and audio discussion between the patient, the emergency physician, and the neurologist. The availability of trained medical practitioners and access to MRI in Lannion currently restrict the times during which telestroke is available, although some telethrombolysis cases have been conducted following a CT scan. This organisation makes it possible to ensure more expeditious accessibility to thrombolysis treatment and discussions with the stroke centre on the indication of thrombectomy.

Telestroke is currently at the project stage between CHU Rennes and Redon hospital (distance from stroke centre), using a mobile procedure based on smart glasses.

Remote assessment by CREBEN (*Centre régional breton d'expertise en neuroradiologie* - Brittany regional centre of neuroradiology expertise) enables remote imaging reviews by an INR and this scheme helps establish indications for MT via direct discussions between the neurologist and the INR. All stroke centres are linked with the INR unit via CREBEN.

### ► Normandy

The conventional telemedicine procedure in Normandy takes place between the emergency physician and the on-duty neurologist at the CHU. Once proximal arterial occlusion has been diagnosed and all other criteria have been met, the emergency physician requests the local SAMU service for information on the availability of the local mobile medical unit, by land or helicopter, and the CHU neurologist checks the inclusion criteria and checks the availability of an INR at the CHU, based on the on-call duty chart previously provided.

- If thrombectomy is feasible at the CHU and approved by the INR, the emergency physician organises transfer without delay with the local EMS service.
- If thrombectomy is not feasible at the CHU, the on-duty neurologist at the CHU contacts another INR unit. The emergency physician at the institution where the patient is located organises transfer without delay with the local EMS service.

### ► Grand-Est

To improve timeliness of care and diagnosis, telestroke has been rolled out in the Lorraine and Champagne-Ardenne areas in some of the region's institutions (as the need is less significant in Alsace due to the number of stroke centres and the less extensive geographic area).

In Alsace, a care protocol is in place with the emergency departments of Mulhouse and Sélestat hospitals, with electronic image transfer from Mulhouse and Sélestat hospitals to the PACS at Colmar hospital.

Only the Lorraine region has organised prehospital services enabling patients to be sent directly to the nearest stroke centre or telestroke unit. In the telestroke unit, the decision to carry out thrombolysis is made jointly by the emergency physicians and the remote expert neurologist. A discussion is under way on the incorporation of thrombectomy in these services, which is currently carried out on a case-by-case basis.

The 2018-2022 Regional Healthcare Plan (PRS2) envisages homogenising care services, particularly by setting out the regional stroke management procedure, including the prehospital phase and the hospital phase (and therefore grading including access to mechanical thrombectomy).

Telestroke is clearly an asset in the organisation of services, although it may be difficult to implement due to the circumstances of some institutions (emergency physician demographic, organisation of 24-hour access to MRI in particular).

Progress is needed on the organisation of access to thrombectomy, with the need to be able to carry out both thrombolysis and thrombectomy. The discussion should also address some localities at a distance from a thrombolysis unit: should be patient be dispatched first to the thrombolysis unit and then to the thrombectomy unit, or directly to the thrombectomy unit?

Problems encountered:

- interfacility transfer and delays penalising patient care;
- difficulty obtaining a helicopter, weather or night-time conditions preventing the helicopter from flying:
  - daytime helicopter transfer (no night-time heliport in Colmar),
  - night-time ambulance transfer;
- difficulty organising medicalised transport of thrombolysis patient;
- discussion on medicalised transport by a nurse.

### ► French Guiana

In French Guiana, the telestroke scheme has been in place with CHU Besançon for six months, with 24-hour access to remote neurological assessment at Cayenne hospital and shortly in the Western French Guiana hospital in St-Laurent and the Kourou Medico-Surgical Centre.

### ► Indian Ocean overseas territory

In the Indian Ocean overseas territory, future users have been associated from the outset in the telestroke project (drafting of framework document, choice of publisher). The issues encountered at the start of activity mostly concerned problems associated with the network (including in Mayotte) and sending images to the regional platform (excessively slow image transfer, slow loading, insufficient display tool functionality).

On the latest services currently at the design stage, problems have been encountered in terms of the system selected and its inclusion in the patient record (by electronic means) at the emergency department of the requesting facility. Healthcare institutions have already installed systems (electronic patient record) and data entry on the regional system is seen to be time-consuming by users. Therefore, work is in progress with the telemedicine platform publisher, to improve local electronic patient record integration.

As regards telemedicine in general, billing issues are recurrent (remote billing without Carte Vitale) as the procedure is time-consuming for users.

The effects of these problems result in practice in:

- underuse of the telestroke scheme for reasons linked with a lack of user-friendliness of the system and its time-consuming nature (e.g. double data entry);
- less referral since radiological images have been available via the PACS enabling enhanced functionality;
- hesitancy on the part of neurologists in respect of the use of telestroke outside the context of stroke cases eligible for thrombolysis (loss of stroke management quality metrics).

Neurological and INR opinions are easily accessible for emergency physicians. A number has been identified in order to link up Mayotte hospital with an expert on Reunion Island. Telephone contact and faxes (not always sent in real time) are preferred. The stakeholders would find this acceptable if there were no medico-legal risks.

## 6.1.6 Hospital phase: organisation of patient admission

The progressive development of stroke centres throughout the territory, particularly under the impetus of the circular DHOS/04 No. 2007-10 8 of 22 March 2007, should enable initial hospital management, organised around stroke centres. Intrahospital neurovascular services should be organised in advance, coordinated with all the stakeholders involved (emergency physicians, neurologists, radiologists, resuscitation specialists, pathologists, etc.) and defined with written procedures. They should prioritise expeditious access to neurovascular expertise and to brain imaging, by optimising the organisation of structural and functional aspects.

Therefore, timely patient dispatch to hospital after the onset of neurological symptoms needs to be coordinated with timely and organised intrahospital care. Indeed, in this phase, times to treatment can represent up to 16% of the total time lost between the onset of stroke symptoms and the CT scan procedure. Therefore, everything must be ready for the patient. **Systematic notification of the admitting departments and professionals involved during patient transport is associated with a reduction in times to intrahospital treatment**. The specific organisation of prehospital emergency case management (call handling, or medicalised transport) is only effective if it can rely on a coordinated hospital handover. Interaction between these two phases optimises treatment times. Moreover, the prehospital call handling service should be aware of the different locations capable of accommodating suspected stroke patients in different institutions, which, depending on the organisation of each institution, may be the emergency or imaging department, or the stroke centre. However, prenotification of the patient's arrival cannot replace the prior definition, in protocol form, of the intrahospital pathway of these patients (15).

### ► Retrospective study by Jadhav *et al. (2017)*

The aim of this study was to describe the transfer procedure for stroke patients with LVO and correlate it with their clinical outcomes. The first group (ED-IA) received intra-arterial therapy, and was

subsequently transferred to the comprehensive stroke centre or the emergency department to receive endovascular therapy, the second group (DAN) was admitted directly to the neuroangiography suite, without receiving prior IA therapy (ED-IV).

The findings reported by this study demonstrate that direct admission to the neuroangiography suite (DAN) is associated with faster hospital arrival to recanalisation times compared to those transferred from emergency departments (ED) (125 minutes *versus* 66 minutes; P=0.001); there is a significant increase in the hospital arrival to groin puncture access time in respect of patients of the ED group *versus* those of the DAN group (81 minutes *versus* 22 minutes; P=0.001); authors' conclusions: the DAN procedure is safe, feasible, and associated with faster times of hospital arrival to recanalisation. The clinical benefit of this approach should be assessed in a prospective randomised trial (63).

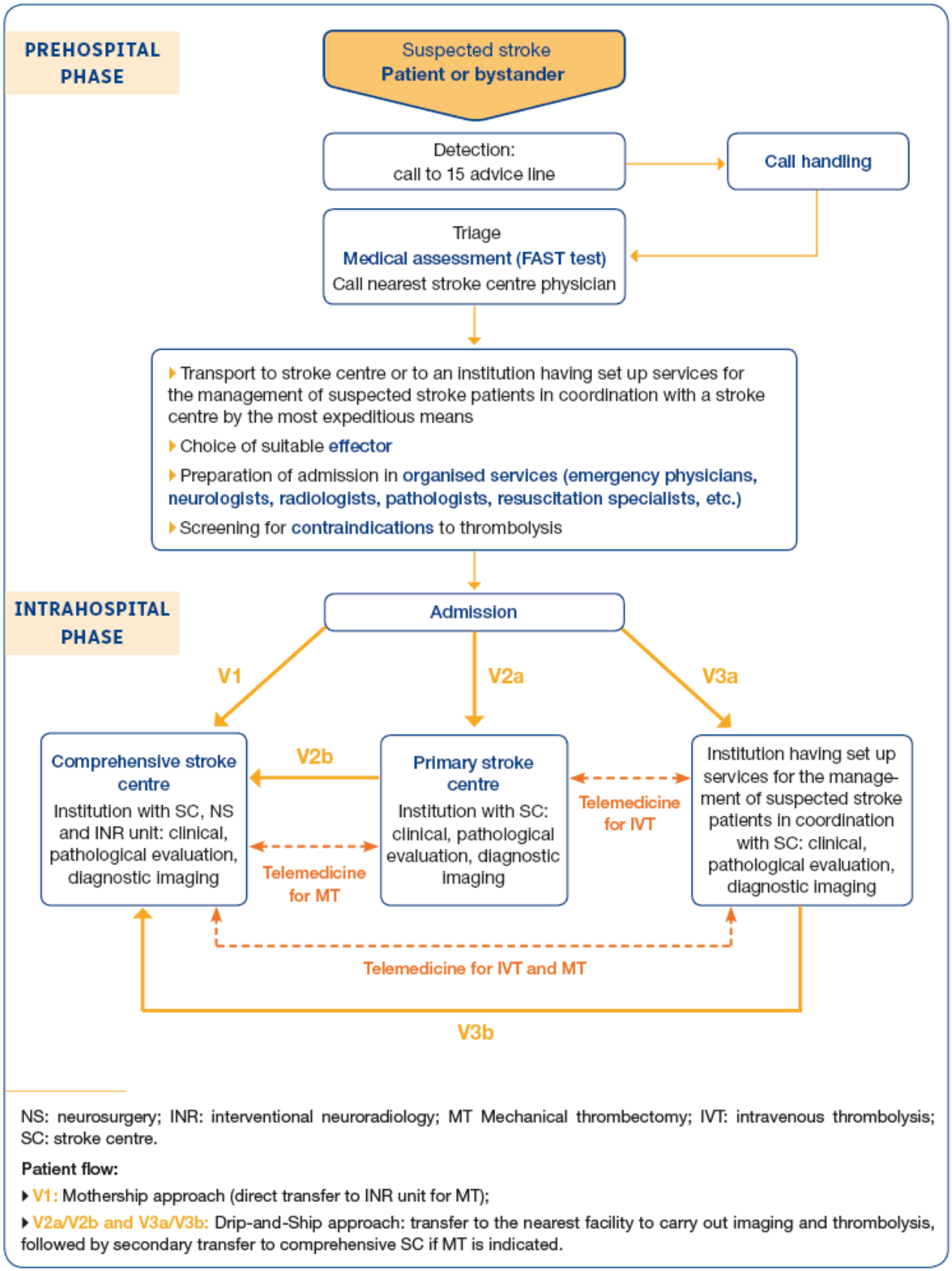
### 6.1.7 Proposed algorithm for the early management of stroke patients (update of the algorithm from the 2009 HAS guidelines)

As stated previously, the initial management of stroke patients is currently based on three types of healthcare institutions:

- healthcare institutions ("comprehensive stroke centres") with:
  - a stroke centre with continuous medical services, 24/7 neurovascular expertise (on duty or on-call), and 24/7 MRI or, failing that, CT brain imaging capability enabling on-site IV thrombolysis,
  - interventional neuroradiology and neurosurgery departments to care for patients requiring specific expertise and specialised neurosurgery and interventional neuroradiology procedures (including MT);
- healthcare institutions ("primary stroke centres") with:
  - a stroke centre with continuous medical services, 24/7 neurovascular expertise (on duty or on-call), and 24/7 MRI or, failing that, CT brain imaging capability enabling on-site IV thrombolysis;
- healthcare institutions with no stroke centre, but attending to emergency cases and provided with protocols, procedures and a technical platform for imaging enabling early management of stroke patients, specific diagnosis and organisation of patient care, by obtaining a neurologist's opinion from a stroke centre with which it is contracted and organising transfer to a stroke centre if required (15).

Furthermore, as described above in section 6.1, the introduction of MT requires a review of the prehospital and intrahospital organisation of early stroke management, particularly in terms of interfacility transfer. Furthermore, the role of telemedicine will also be reinforced, as it will now be used remotely to establish the indication of thrombolysis and MT. For a schematic representation of these new alternative organisations, two algorithms are proposed, detailing "*mothership*" and "*drip and ship*" type organisations.

**Algorithm for the early management of IS patients with IVT and MT: prehospital and intrahospital phase (update of the algorithm from the 2009 HAS guidelines).**

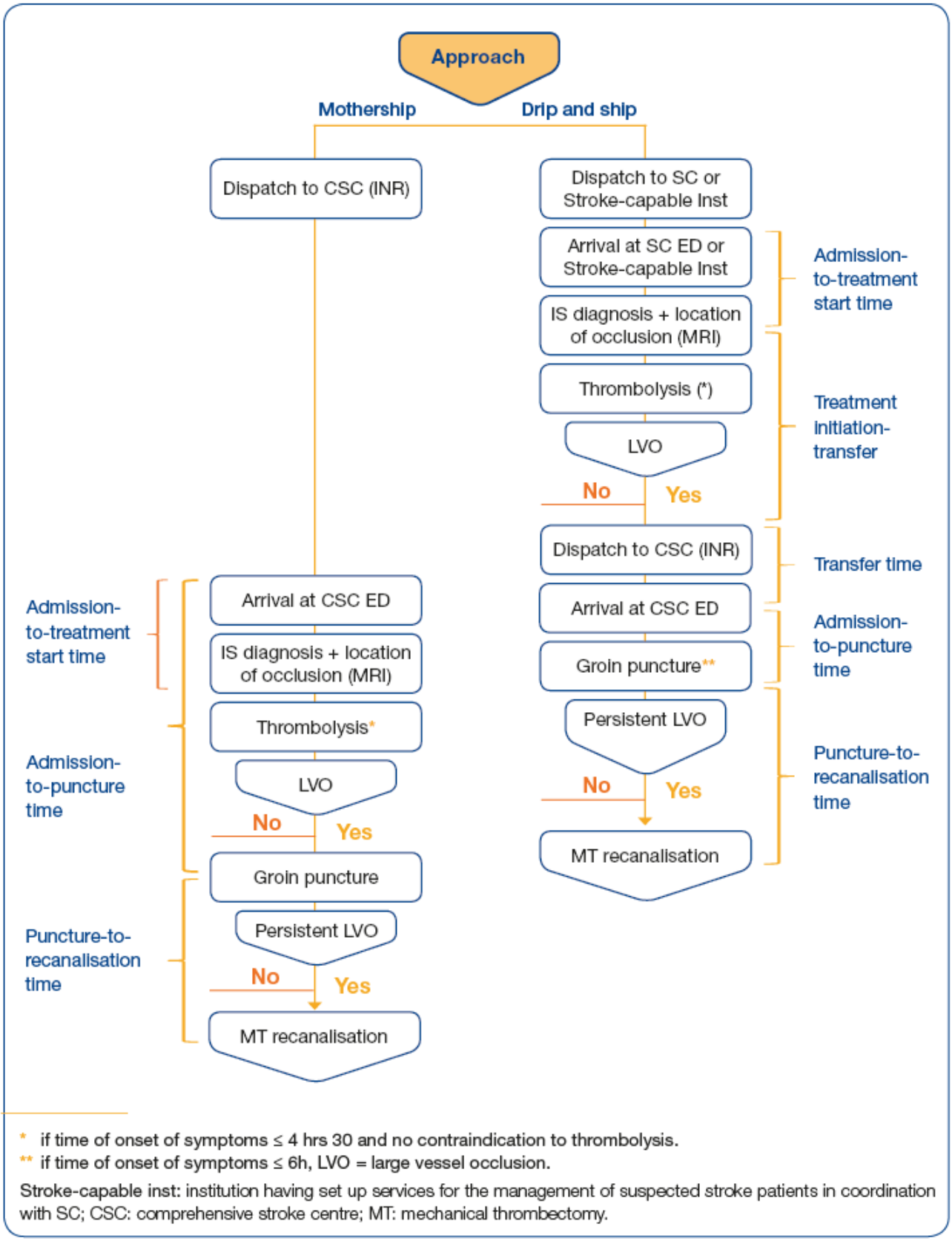



NS: neurosurgery; INR: interventional neuroradiology; MT Mechanical thrombectomy; IVT: intravenous thrombolysis; SC: stroke centre.

**Patient flow:**

- V1: Mothership approach (direct transfer to INR unit for MT);
- V2a/V2b and V3a/V3b: Drip-and-Ship approach: transfer to the nearest facility to carry out imaging and thrombolysis, followed by secondary transfer to comprehensive SC if MT is indicated.

**Diagram of the early management of IS patients with MT in the in-patient phase: the diagram describes treatment delays between the "*mothership*" approach on the left *versus* the "*drip and ship*" approach on the right.**



### 6.1.8 Foreseeable impact on the organisation of care according to intracranial revascularisation device manufacturers

According to the manufacturer of the intracranial revascularisation device SOLITAIRE™ 2, "*the use of mechanical thrombectomy does not impact the organisation of care in terms of a change of practices since this procedure should be conducted in an interventional neuroradiology department. These departments are already organised with a multidisciplinary team, including at least one qualified interventional neuroradiologist, one anaesthetist and resuscitation specialist assisted by a state-qualified anaesthesia nurse and radiographers to treat intracranial aneurysms or intracranial arteriovenous malformations*" (64).

According to the manufacturer of the Trevo ProVue and Trevo (XP) ProVue system, known as a "*stent retriever*", "*mechanical thrombectomy requires, like thrombolysis, expeditious patient diagnosis and care. This is an interventional neuroradiology procedure conducted in SIOS-accredited centres according to the decrees in relation to establishment and operational requirements (2007-366/367) by practitioners meeting the requirements of the order of 15 March 2010. Therefore, it is critical that patients liable to benefit from this therapy arrive at these centres as quickly as possible"* (65).

### 6.1.9 Patient-centred care

#### ► Review of the implications of endovascular therapy for the organisation of stroke systems of care in North America (2015)

According to this review, the treatment effect on the modified Rankin scale, which discriminates between different patient-valued health outcome states, validates endovascular thrombectomy as a treatment that improves patient-centred outcomes. It recommends further analysis of the trial data to explore other patient-centred outcomes, including quality of life, mood, cognition and function, including the ability to live independently in a private residence.

In the authors' view, given the large differences in patient-centred disability outcomes, the authors of the review recommend that physicians should proceed without delay to thrombectomy in cases where the patient is without capacity for informed consent and no legally authorised representative is available. Hospitals and other healthcare organisations should establish protocols that explicitly recommend that the physician act under the doctrine of implied consent, based on what a reasonable patient would choose in this scenario, much as would be expected for a patient with acute coronary syndrome or cardiac arrest (31).

#### ► Overview of the position of *Association d'aide aux patients et aux familles de patients victimes d'AVC*

In order to identify users' concerns in terms of care provision and the patient pathway, a questionnaire approach was used covering the various aspects (accessibility, doctor-patient relationship, continuity, "perceived" clinical quality, organisation of care). According to *Association d'aide aux patients et aux familles de patients victimes d'AVC*, the general public is very ill-informed on the early stroke management pathway and the little information available on endovascular therapy is relatively clear. The association states that, while information was indeed provided to patients and their relatives, it could be clearer. Nevertheless, in the acute phase, information is frequently misunderstood and not accepted.

Patients and families seek quality care to which they consider themselves entitled; moreover, some patients would like, insofar as possible, an active role in the early management of stroke, particularly when decisions involving them are made. As regards the stroke management pathway, discussions on this topic are currently taking place within the association, particularly in respect of improving collaboration with stroke centre leaders. Finally, the impetus created by the Stroke Plan is worth supporting in the view of the patient association.

The points of view expressed by the patient association are presented in full in Appendix 6.

## 6.2 COPIL position on the care pathway of the MT candidate patient

The neuroscience expert of the IDF regional health board, and COPIL member, has pointed out that, according to the 2007 circular on the role of stroke centres in stroke management, emergency departments included in stroke services and assessing stroke cases with a view to conducting thrombolysis or not by means of telemedicine are not stroke centres in accordance with official legislation. Moreover, SFNV states that, in France, the terms used to describe stroke centres are *UNV de territoire* (primary stroke centre) and *UNV de recours* (comprehensive stroke centre).

According to SNFV, MT cannot be envisaged as an isolated procedure, as patients require medical care before, during, and after the MT procedure. It would be harmful to envisage MT outside neurovascular services (call handling, emergency department, radiology, stroke centre), and all patients should be admitted to a stroke centre. If any one of the stakeholders in these services is lacking, the entire information transfer and care chain is compromised. In respect of the section on interfacility transfer, the IDF regional health board notes that the report does not feature a discussion on the mode of transportation used for patients.

According to SFMU, emergency medicine is not sufficiently taken into account, particularly in terms of intra- and extrahospital feasibility of treatments, referral to comprehensive stroke centres, and optimisation of training resources and requirements.

According to the patient association queried[18], the little information available on the stroke management pathway, and in particular on MT therapy, is relatively clear; however, it points out that, in the acute phase, this information is frequently misunderstood and not accepted. Some patients and families would like, insofar as possible, an active role in the early management of stroke, particularly when decisions involving them are made.

**Findings in respect of the care pathway of the MT candidate patient**

**MT candidate patient pathway**

The patient pathway includes a number of stages:

- prehospital phase: patient call and dispatch to stroke centre or healthcare institution linked to stroke centre via telemedicine;
- patient selection based on neurological examination and cerebrovascular imaging: in the case of telemedicine, the clinical examination is conducted by the neurologist and the radiological interpretation is carried out by a radiologist with vascular neuroradiology expertise;
- establishment of MT indication: neurological and neuroradiological consultation on-site or via remote assessment;
- contact of anaesthetist;
- dispatch to stroke centre equipped with an MT unit or INR unit - MT procedure;
- return to specialised ward in stroke centre or to neurointensive care unit or comprehensive stroke centre;
- **detection: information and awareness.**

Note: the description of detection procedures (15 emergency advice line, call handling, emergency medical services, etc.), provided in this report, is based on the current organisation and regulations. This description will be subject to change in the event of modifications of the organisation and regulations of detection procedures.

[18] *Association d'aide aux patients et aux familles de patients victimes d'AVC*.

Activation of the alert by calling the 15 emergency advice line, call handling and urgent dispatch to an identified hospital are critical for expeditious patient care and enable MT procedures under optimal conditions.

Information in general public campaigns on early management of stroke cover the following three main areas:

- identifying symptoms indicating a potential stroke;
- the existence of emergency care and treatments (admission to stroke centre and thrombolysis);
- the need for emergency aid as a matter of priority by contacting the centre 15 advice line.

The key messages to be broadcast to professionals providing stroke management services include the need to:

- consider any sudden, transient or sustained neurological deficit as an absolute emergency;
- record the precise time of the onset of symptoms;
- be aware of the effectiveness of the care provided in stroke centres;
- be aware of specific therapies for stroke.

**In the prehospital phase**

**Patient assessment:**

- Early management is critical in cases of stroke; during the prehospital phase, professionals should be provided with simple tools suitable for timely use.
- The FAST score (acronym meaning *face, arm, speech, time*) is simple and universally accessible and is used to assess the likelihood of stroke in suspected cases. Awareness should be raised among primary care teams, other healthcare personnel and the entourage of at-risk patients on the early symptoms of stroke, and training provided on the use of the FAST test. Moreover, all emergency physicians should be capable of using the NIHSS scale (*National Institutes of Health Stroke Scale*) and assessing stroke severity.

**Call handling:**

- The role of EMS call handling and prehospital patient transportation, which is already critical in stroke services, should be reinforced further in thrombectomy management.
- The primary aim is to get the patient to the right place at the right time: operational stroke services should be activated by calling the 15 advice line, guaranteeing a rapid response and expertise; the EMS call handling centre understands the urgency of the call, and transfers it without delay to the triage physician, who deciphers the symptoms suggestive of stroke provided by the entourage and requests a transfer via the most expeditious means available.

**Patient transfer:**

- Intra- and interfacility transfer protocols and procedures guaranteeing safe and effective care for patients should be defined and adopted in advance. These protocols should enable efficient transfers at all times, even during out-of-hours services. In cases of medicalised transport, it is recommended to take blood samples enabling laboratory profiling.
- All suspected stroke patients should be transferred to the nearest stroke centre, regardless of administrative boundaries. Failing a stroke centre nearby, the patient is transferred to an institution with an emergency department and, if possible, a neu-

rology department or unit. The emergency department must have implemented a protocol for stroke management in the context of neurovascular care services, thereby enabling the patient to receive care as quickly as possible. Telemedicine linked with the reference stroke centre makes it possible to delegate the intravenous fibrinolysis procedure to the emergency physician, before transferring the patient to the nearest INR unit.

The two potential models for MT may be described as follows:

- "***drip and ship***" (two-phase transfer): initial transfer to the nearest primary stroke centre for diagnosis and intravenous thrombolysis, followed by expeditious transfer to an INR unit for MT;
- "***mothership***": direct transfer to comprehensive stroke centre capable of carrying out thrombolysis, MT, and other required neuroscience support services.

**The optimal model is dependent on the regional network, population density, transport infrastructure and distance from the INR unit.**

"*Drip and ship"* might be the more appropriate solution for more remote areas, while a "*mothership*" model might be a good solution for urban city populations which are generally close to a comprehensive stroke centre. However, while preliminary data of a low level of evidence suggest a lack of significant difference between the two models, randomised controlled prospective clinical trials (ongoing or in the pipeline) are needed to establish a definitive opinion.

**Telestroke in the care pathway**

- The telestroke scheme (*cf.* section 1.1.4) enables neurovascular and radiological expertise to be shared with institutions where it is not available. In many localities, it enables access to this expertise within shorter time-frames.
- Telestroke networks are useful for triaging stroke patients who may be eligible for interfacility transfer in order to be considered for MT.
- In view of the limited distribution and availability of neurological, neurosurgical, and radiological expertise, the use of telemedicine/telestroke resources and systems may bridge this gap and should be supported by the healthcare system.
- Adequate 24/7 coverage should be available for the care of acute stroke patients.

**In the hospital phase**

- The progressive development of stroke centres throughout the territory in particular, and the structuring of care services should enable initial hospital management, organised around stroke centres. Intrahospital neurovascular services should be organised in advance, coordinated with all the stakeholders involved (emergency physicians, neurologists, radiologists, resuscitation specialists, pathologists, etc.) and defined with written procedures. They should prioritise expeditious access to neurovascular expertise and to brain imaging by optimising the organisation of structural and functional aspects.

**Hospital admission**

- Therefore, timely patient dispatch to hospital after the onset of neurological symptoms needs to be coordinated with timely and organised intrahospital care. The specific organisation of prehospital emergency case management (call handling, or medicalised transport) is only effective if it can rely on a coordinated hospital handover. Interaction between these two phases optimises treatment times. Moreover, the prehospital call handling service should be aware of the different locations capable of accommodating suspected stroke patients for the different institutions. Depending on the organisation of each institution, these may be the emergency, imaging department, or stroke centre.

- Patients eligible for MT are selected subject to a multidisciplinary review including a neurologist, a neuroradiologist and an anaesthetist based on the clinical examinations and imaging findings, obtained on-site or forwarded via telemedicine. The first procedure is to carry out brain imaging with a view to confirming cerebral infarction.

**Patient information and consent**

- The effect of MT on disability makes it a worthwhile therapy that improves patient-centred outcomes. It is recommended that physicians should proceed without delay to MT in cases where the patient is without capacity for informed consent and no legally authorised representative is available. Hospitals and other healthcare organisations should establish protocols that explicitly recommend that the physician act under the doctrine of implied consent, based on what a reasonable patient would choose in this scenario.

# 7. Overview of care provision in France

The SIOS data on MT care provision described below are supplemented by the findings of the survey conducted on regional health boards and professionals.

In France, one of the greatest challenges for improving patient access to endovascular therapy could be that of reorganising the boundaries currently set by the geographic distribution of INR units. The short- and medium-term future of early management of IS should focus on a single objective, obtaining equality of access to mechanical thrombectomy in terms of time to treatment and guaranteed interventionalist expertise.

The first geographic challenge is found in the first stage of stroke centre management; merely 50% of stroke cases are admitted to one of the 137 stroke centres (60% in Paris). As mentioned previously, this initial patient dispatch remains critical. Subsequently, transfer to an INR unit for the MT procedure should meet certain requirements to enable equality of access to care. According to the narrative review by Berge *et al.* presented at the SFNR conference in 2016 (56) and the updates on the regional organisation in Nouvelle-Aquitaine dated January 2018[19], most CHUs are evenly distributed within the regions, but some "remote localities" remain, such as Annecy, Bayonne, La Rochelle, Pau, Perpignan, Vannes, Boulogne, Valence, Valenciennes, Corsica, Fort de France. The authors of the review state that "*the creation of secondary MT units should be envisaged according to ESO and ESMINT criteria adapted by SFNR in February 2015:*

- *where the stroke centre is over 130 km or 90 min from the nearest MT unit;*
- *where the population catchment area includes at least 300,000 inhabitants and where the number of IVT cases envisaged in the stroke centre is at least 150/year by 2018;*
- *finally, these facilities should include skilled practitioners having validated a training model which has yet to be defined by national learned societies"*.

The second challenge lies in providing adequate human resources to enable 24/7 services. In daytime activity, the neuroradiologist should be immediately available for the joint review of the record of the patient admitted to the stroke centre to establish the MT indication, hence ruling out any embolisation in progress by the same practitioner; therefore, at least two must be present. During on-call periods, the organisational and legal constraints are such that the minimum number is at least four per centre, regardless of the number of MT cases.

## 7.1 Interregional Schemes of Healthcare Organisation

The aim of the Interregional Schemes of Healthcare Organisation (SIOS) is to optimise the response to healthcare needs by ensuring synergy of expertise while retaining a good degree of accessibility to care provision for the areas concerned. These aspects are therefore defined in principle by the Regional Hospitalisation Agencies (ARH). The SIOS are structured based on the same principles as third-generation Regional Schemes of Healthcare Organisation (SROS).

Seven interregions were defined by the order of 24 January 2006:

- Antilles-French Guiana interregion, made up of French Guiana, Guadeloupe and Martinique (66);
- East interregion, made up of Alsace, Burgundy, Champagne-Ardenne, Franche-Comté and Lorraine (67);
- North-West interregion, made up of Lower Normandy, Upper Normandy, Nord-Pas-de-Calais and Picardy (68);
- West interregion, made up of Brittany, the Centre, Pays-de-la-Loire and Poitou-Charentes (69);
- South-East interregion, made up of Auvergne and Rhône-Alpes (70);

[19] Le point sur l'organisation régionale en Nouvelle-Aquitaine au 1er janvier 2018, Jérôme Berge, Bordeaux; DGOS. Paris 1 February 2018.

- South-Mediterranean interregion, made up of Corsica, Provence-Alpes-Côte-D'azur and Languedoc-Roussillon (71);
- South-West interregion, made up of Aquitaine, Limousin and Midi-Pyrénées.

By way of derogation, Ile-de-France and Reunion Island have an SROS for activities falling in principle within the remit of an SIOS (*cf.* order of 15 June 2010).

The SIOS accounts for a number of factors: current activity volumes, technical development, medical demographic. It is also required to develop links with some areas of the SROS and reinforce the interregional aspects of healthcare organisation.

The SIOS covers six areas defined by regulations: neurosurgery, interventional neuroradiology, heart surgery, severe burn injuries, organ transplantation, haematopoietic cell transplantation.

The areas covered by the SIOS all include an SIOS I evaluation, establishing an overview of achievements and current care provision on the interregion. The distribution of the facilities is analysed, as are the activities of the different centres, along with outflow rates and respective influences of the institutions in the region. These evaluations then establish the challenges and issues not resolved by the SIOS that is coming to an end and the emerging challenges and issues due to medical and procedural progress, changes in needs, and new therapeutic indications.

Finally, they propose lines of conduct according to the areas and specify the operational measures proposed. These operational measures represent targets to be achieved within the interregion. Once the SIOS has been adopted and defined, its measures become enforceable in institutions for these six regulatory areas.

All of the SIOS documents analysed agree and highlight the prospect of MT development which represents a challenge for interventional neuroradiology teams. This activity requires the shortest possible time to treatment after the onset of stroke (six hours) and therefore 24-hour availability of a medical and paramedical team.

This implies faultless organisation of care services, in order to carry out:

- accurate diagnosis as early as possible;
- a review between the stroke centre vascular neurologists and interventional neuroradiologists of the potential indication of endovascular therapy;
- immediate patient transfer to an interventional neuroradiology centre if the indication is established;
- optional secondary patient transfer after the procedure, to the local stroke centre.

According to the SIOS schemes, the potentially foreseeable increase in MT procedures is driving growth in interventional neuroradiology teams and general anaesthesia teams (for a portion of these procedures).

Each region must organise the neurovascular services for its own locality. Harmonious development of interregional telemedicine (telestroke) in terms of interventional neuroradiology activities will particularly make it possible to envisage sharing expertise (telemedicine) between INR units, based on models to be defined with the stakeholders concerned.

## 7.2 ARS survey: current regional organisation of early management of stroke

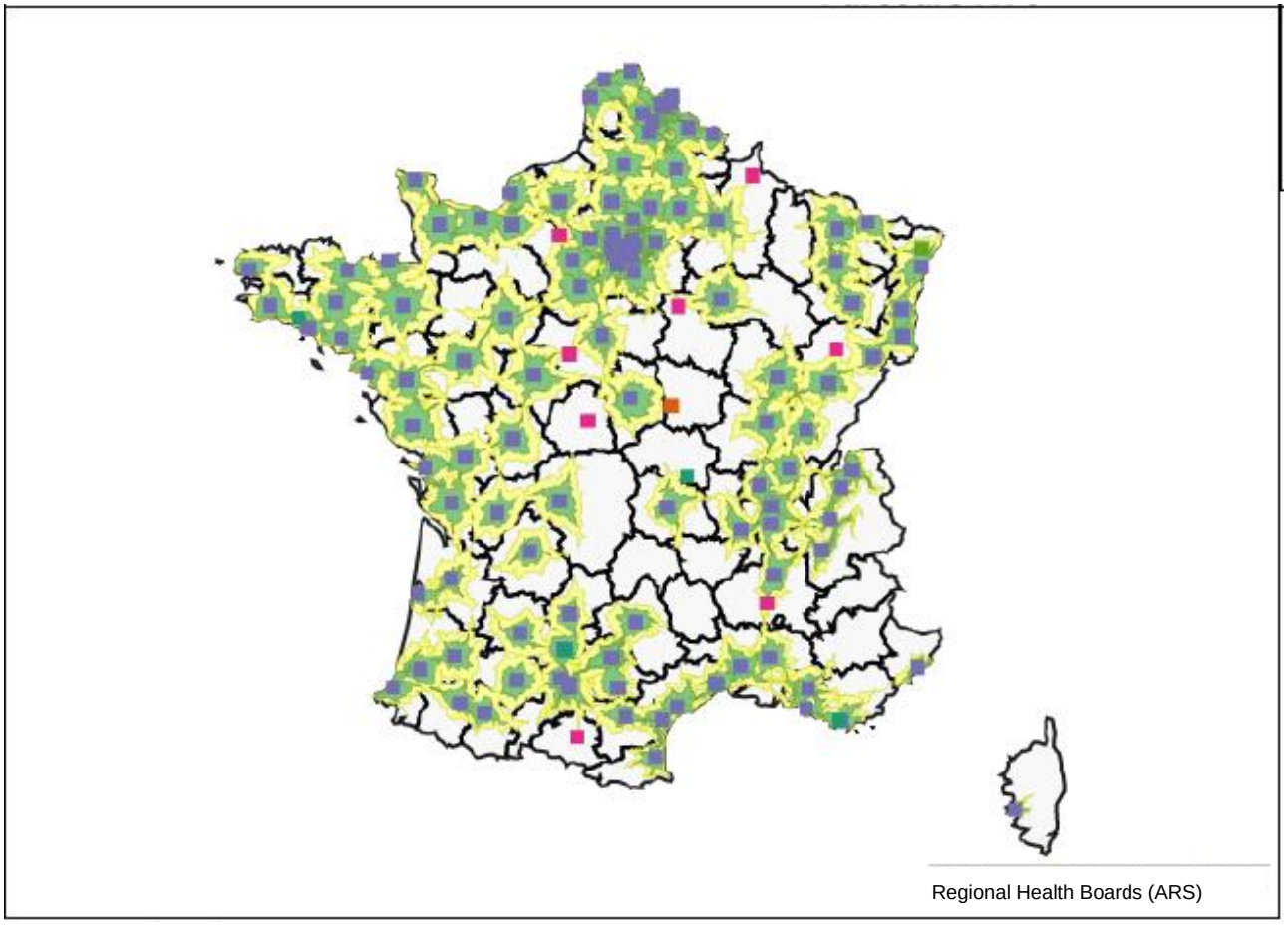
The management of patients requiring emergency thrombectomy in a cerebral infarction context falls within the remit of the regional organisation of stroke care. It is envisaged around stroke services including the emergency medical services, institutions with 24-hour emergency departments (MCO facilities authorised to accommodate adult emergency cases), institutions with a primary stroke centre and institutions with a comprehensive stroke centre supported by neurosurgery (NS) and interventional neuroradiology (INR) departments. Telemedicine, with schemes such as the

ORTIF TELENEURO telemedicine system installed in the different institutions with stroke services, helps make neurological expertise available to hospitals with no stroke centre (72).

Optimal organisation of the care pathway of ischaemic stroke patients targets the following objectives:

- improve access to care:
  - offer rt-PA + MT bi-therapy to a maximum number of patients. This target is important because almost 10% of ischaemic stroke patients are eligible for rt-PA, and 15% of stroke patients eligible for rt-PA may benefit from MT (29),
  - provide a maximum of patients with timely access to bi-therapy, by reducing pre- and intra-hospital time delays, which are a major concern in acute stroke care,
  - require highly specialised human and technical resources with highly experienced teams for endovascular interventional neuroradiology procedures,
  - provide out-of-hours services via the organisation of an interfacility cooperation network, pooling of medical resources with the use of telemedicine for the care of neurosurgery and neurovascular patients;
- improve efficiency:
  - anticipate the adaptation of care provision to make it possible to provide care for a greater number of patients, given the growth in the use of these interventional procedures, particularly as a replacement for neurosurgery procedure and for the treatment of some neurovascular patients,
  - group the activity on a limited number of facilities to help optimise human and technical resources in each unit, guarantee safety of care and control costs through more appropriate care provision.

### 7.2.1 Current regional care provision network

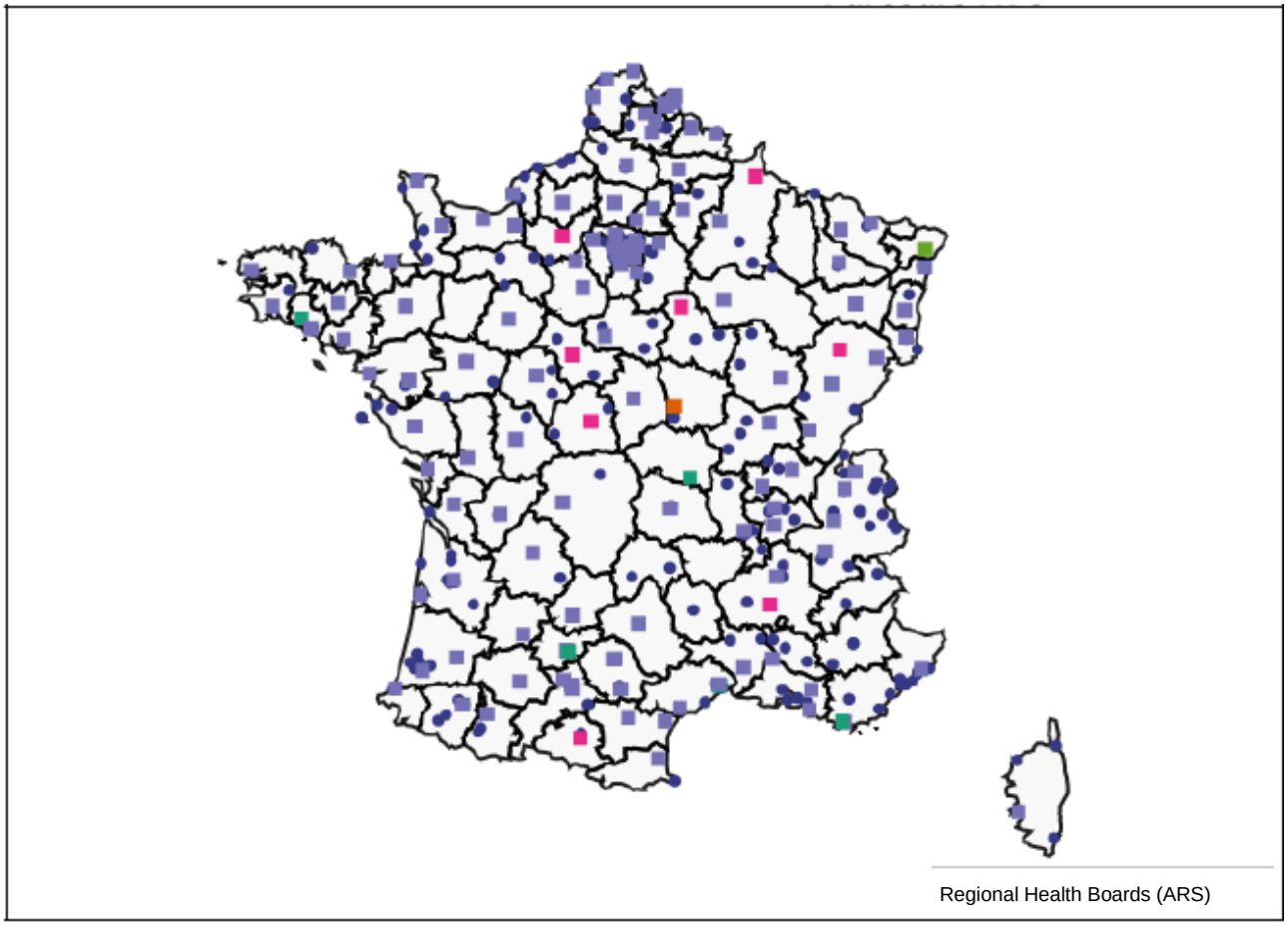


PROVISION
Stroke management
Stroke Centres
- Accredited and active
- Planned accreditation
- Not accredited
- Closed
- Undefined status

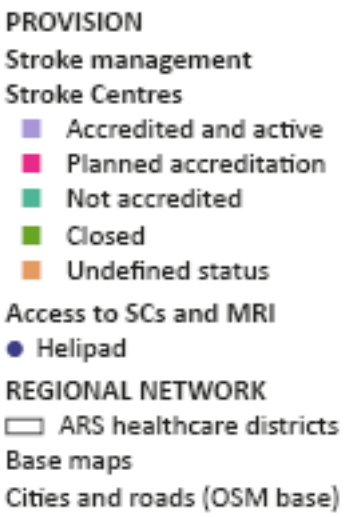
Access to SCs and MRI
- Isochrones within 30 minutes of accredited SCs
- Isochrones within 45 minutes of accredited SCs

REGIONAL NETWORK
- ARS healthcare districts

Base maps
Cities and roads (OSM base)



Regional Health Boards (ARS)




*Map references: All rights reserved. Document printed on 19 September 2017, server Prodige V4.0, https://carto.atlasante.fr,Service:cartes*

### ► Ile-de-France

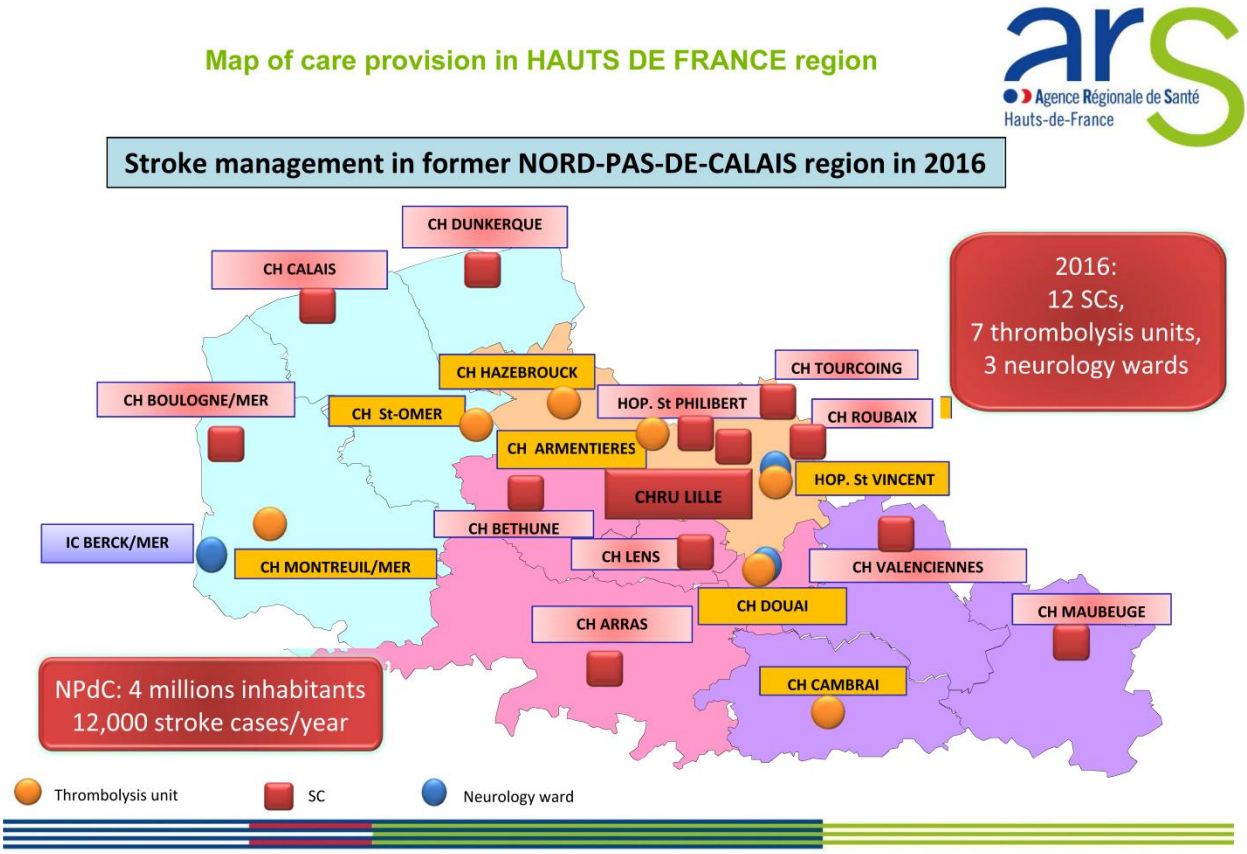
The region includes twenty-one stroke centres including one paediatric centre:

- seven stroke centres are located in institutions authorised for neurosurgery and interventional neuroradiology activities;
- no INR-capable stroke centre in the greater metropolitan area.

### ► Hauts-de-France

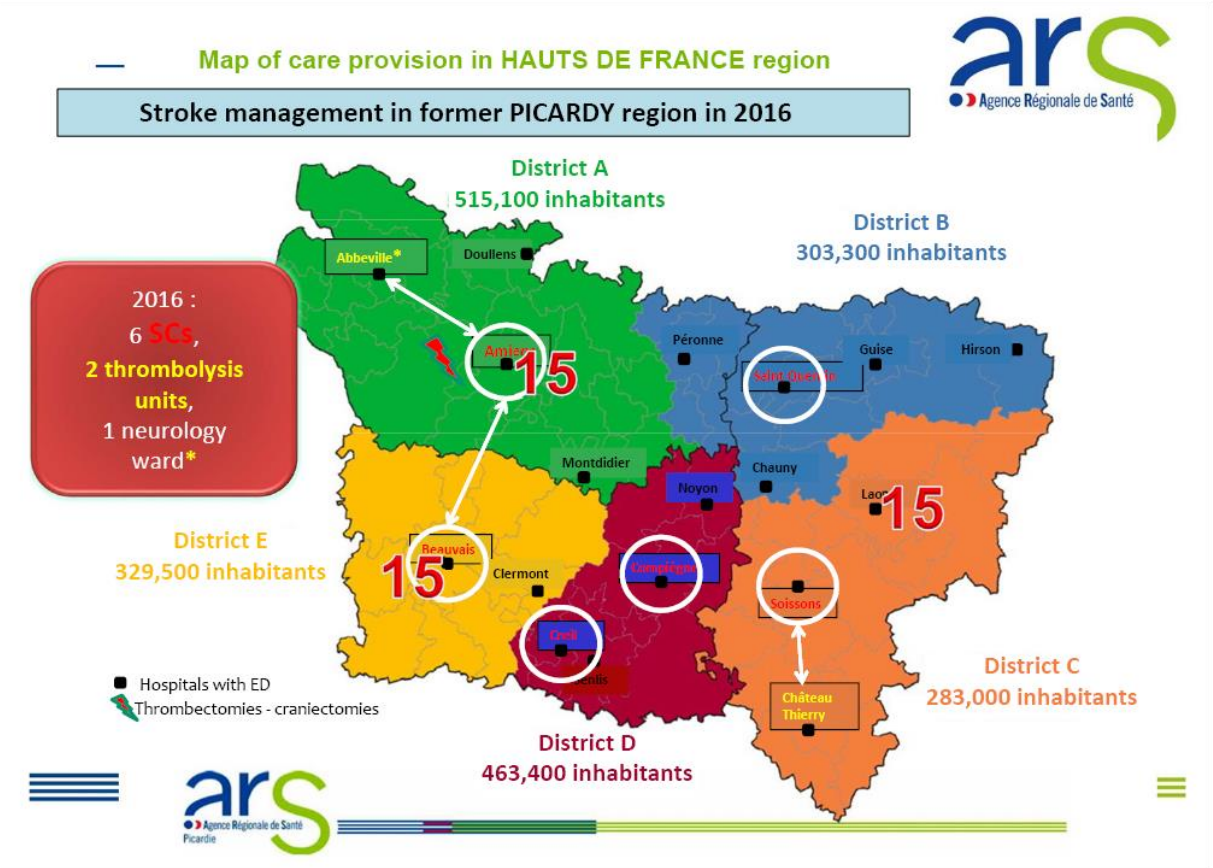
#### Map of former Nord-Pas-de-Calais (NPDC) region in 2016

- twelve stroke centres;
- seven thrombolysis units;
- three comprehensive neurology wards.



### Map of former Picardy region in 2016

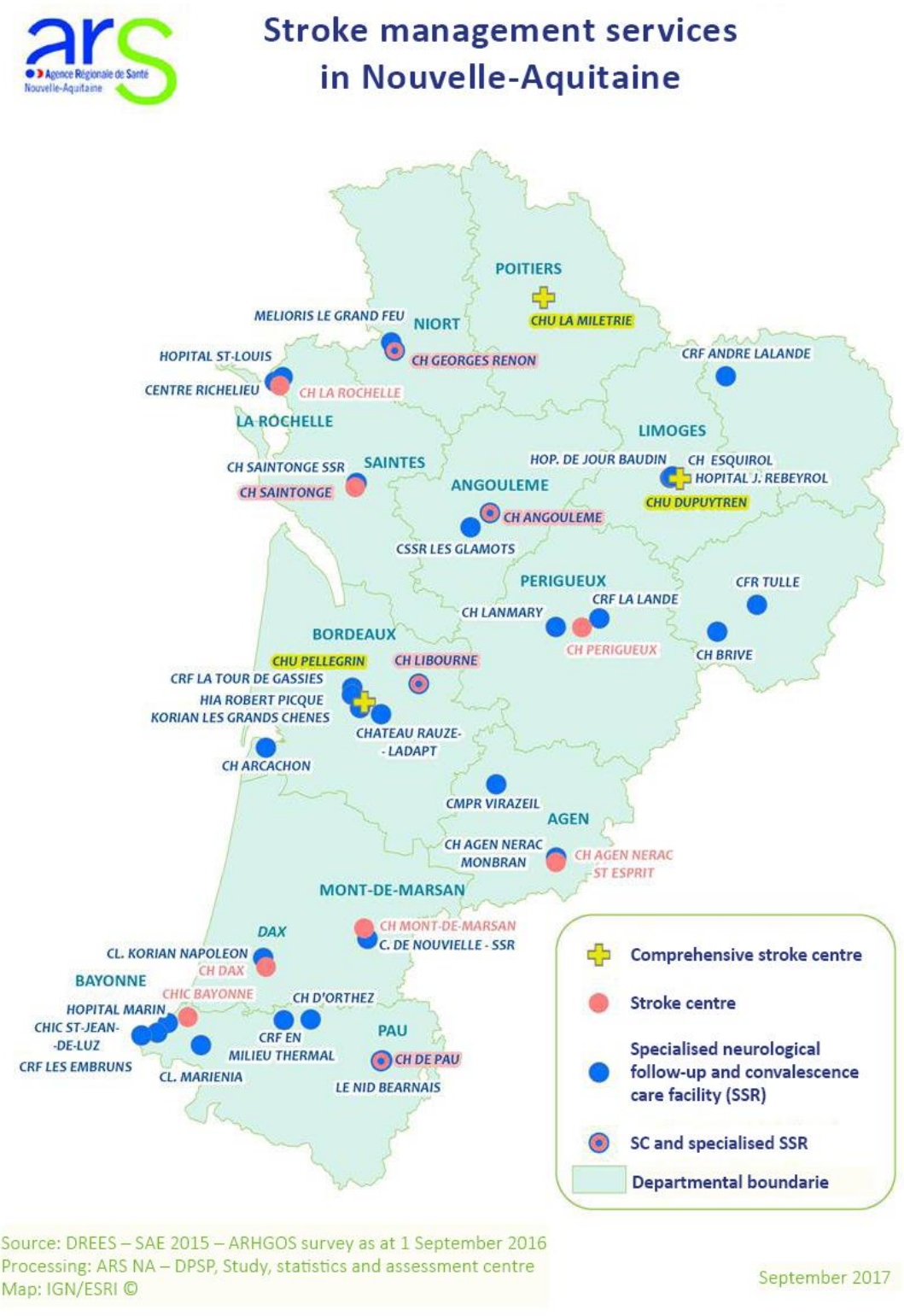
- six stroke centres;
- two thrombolysis units;
- one comprehensive neurology ward.




Telemedicine systems in place, for IVT and MT:

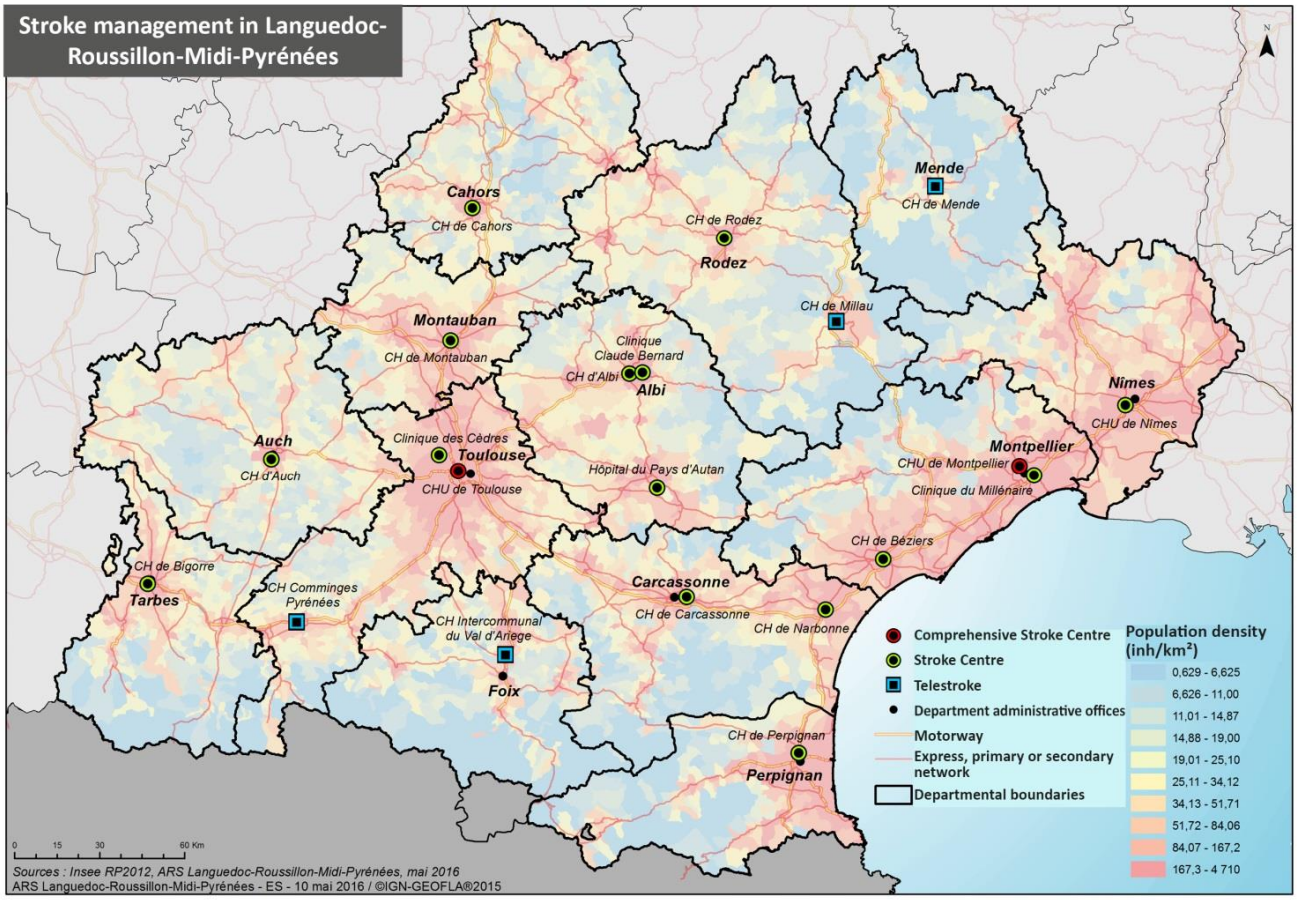
- the Hainaut-Artois telestroke scheme, these six hospitals are connected 24/7 via the telestroke system for all CHU referral including MT;
- the Littoral telestroke scheme, these six hospitals without telemedicine capability benefit from 24-hour CHU referral for MT;
- the Métropole-Flandre Intérieure telestroke scheme, these six hospitals without telemedicine capability benefit from 24-hour CHU referral for MT;
- the three telestroke schemes in the former Picardy region have telemedicine access every two weeks or on a 24-hour basis.

## ► Nouvelle-Aquitaine




- fourteen stroke centres including three institutions with an INR unit.

## ► Occitanie




The Occitanie region includes seventeen stroke centres, including three institutions authorised for interventional neuroradiology (INR). Two of these institutions have been identified as regional comprehensive stroke centres: CHRU Montpellier and CHRU Toulouse.

Two telemedicine schemes are also in place:

- remote assessment (via image transfer) between primary stroke centre and comprehensive stroke centre and INR departments: for requests for advice for MT and for complex cases directed at neurologists and interventional neuroradiologists;
- telemedicine (remote consultation and image transfer) between emergency departments located in orphan facilities and primary stroke centre: for neurological advice and tele-thrombolysis if required.

## ► Burgundy and Franche-Comté

### Former region of Burgundy and Sud-Haut-Marnais (SHM)

In 2017, the region includes two NICU units (one seniorised neurovascular service and one INR unit at CHU Dijon and one seniorised neurovascular on-call service at Chalon-sur-Saône hospital); it also carries out tele-fibrinolysis procedures with nineteen general hospitals, meaning that this region ranks second after Ile-de-France in terms of regional network density.

An ARH-accredited private practice-hospital acute and posthospital stroke care network and a telestroke network sending brain images to the CHU Dijon stroke centres, known as the ReBoN network (*Réseau Bourgogne Neuro* - Burgundy Neuro Network) was set up in 2003. In 2011, the ReBoN telestroke network saw major technological changes, enabling remote patient consultation, remote brain imaging assessment, remote support for the tele-fibrinolysis procedure and remote

monitoring for patients not transferred to Dijon or transferred from Dijon, to comply with the 2010 Stroke Plan and the 2011 TLM Plan.

### Former Franche-Comté region

This region includes eight hospitals receiving 3500 stroke cases/year.

Three stroke centres (two local: Lons-le-Saunier and Belfort-Montbéliard hospitals and one comprehensive stroke centre at CHU Besançon with a seniorised service and a junior service). It has a single INR unit at the Besançon comprehensive stroke centre.

All centres have been equipped with telemedicine systems since the early 2000s. Over 2000 teleneurology procedures/year, including 40% telestroke cases, are carried out.

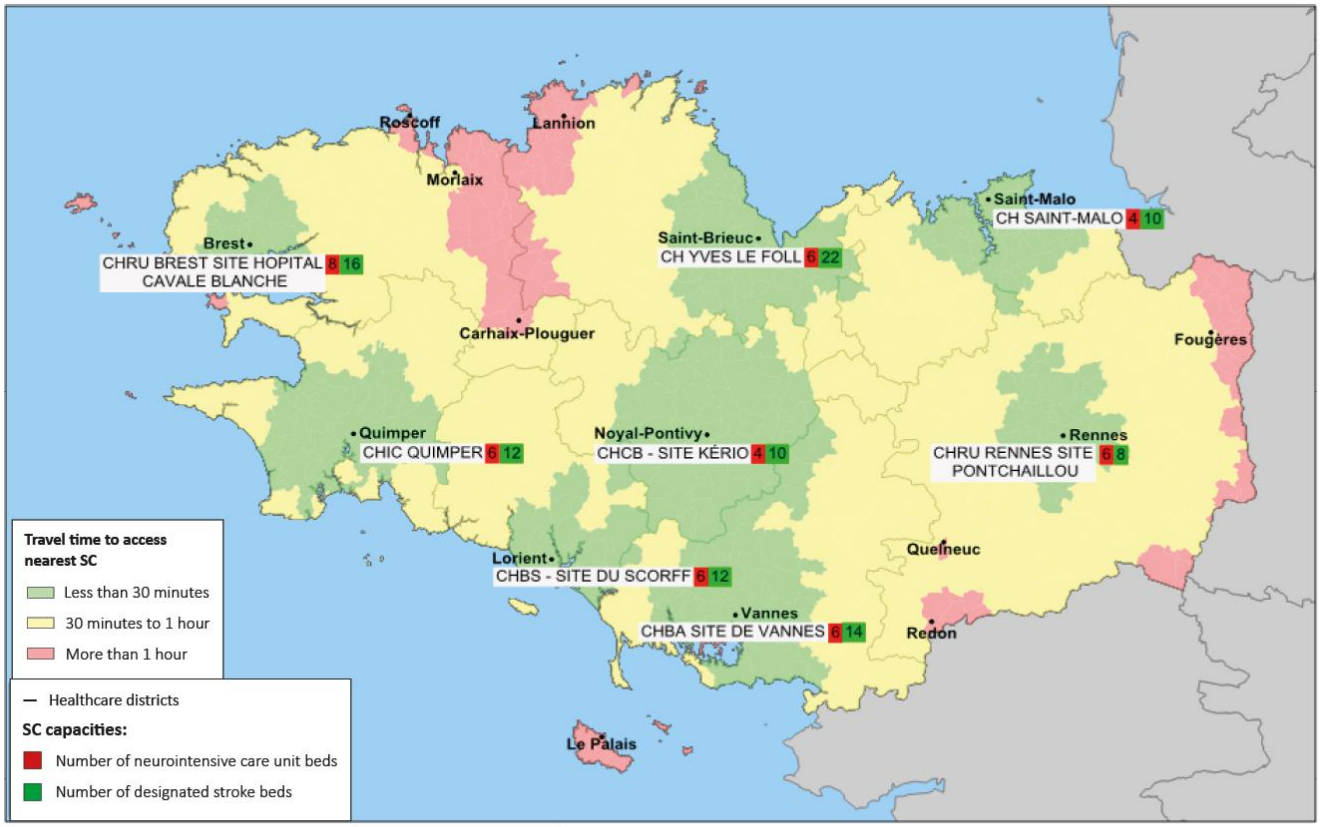
## ► Centre-Val-De-Loire

The only interventional neuroradiology (INR) centre with mechanical thrombectomy (MT) available in the Centre-Val-de-Loire region (CVL) is located at CHU Tours. In this facility, 24-hour access to services or an operational on-call service is available with:

- neurovascular ICU;
- neurosurgery;
- diagnostic or interventional neuroradiology.

The telestroke scheme in the Centre-Val-De-Loire region is based on the COVOTEM platform which is used exclusively for thrombolysis alerts.

## ► Brittany




Source: ARHGOS (authorisations), ARD Bretagne (capacities) as at 01/01/2015
Produced by ARS Bretagne, September 2015
Map produced with Cartes & Données – © Articque

The organisation in Brittany is based on a radial network with eight stroke services centred around eight stroke centres, including two comprehensive stroke centres in the two university hospitals, CHU Rennes and Brest, with INR and neurosurgery capability.

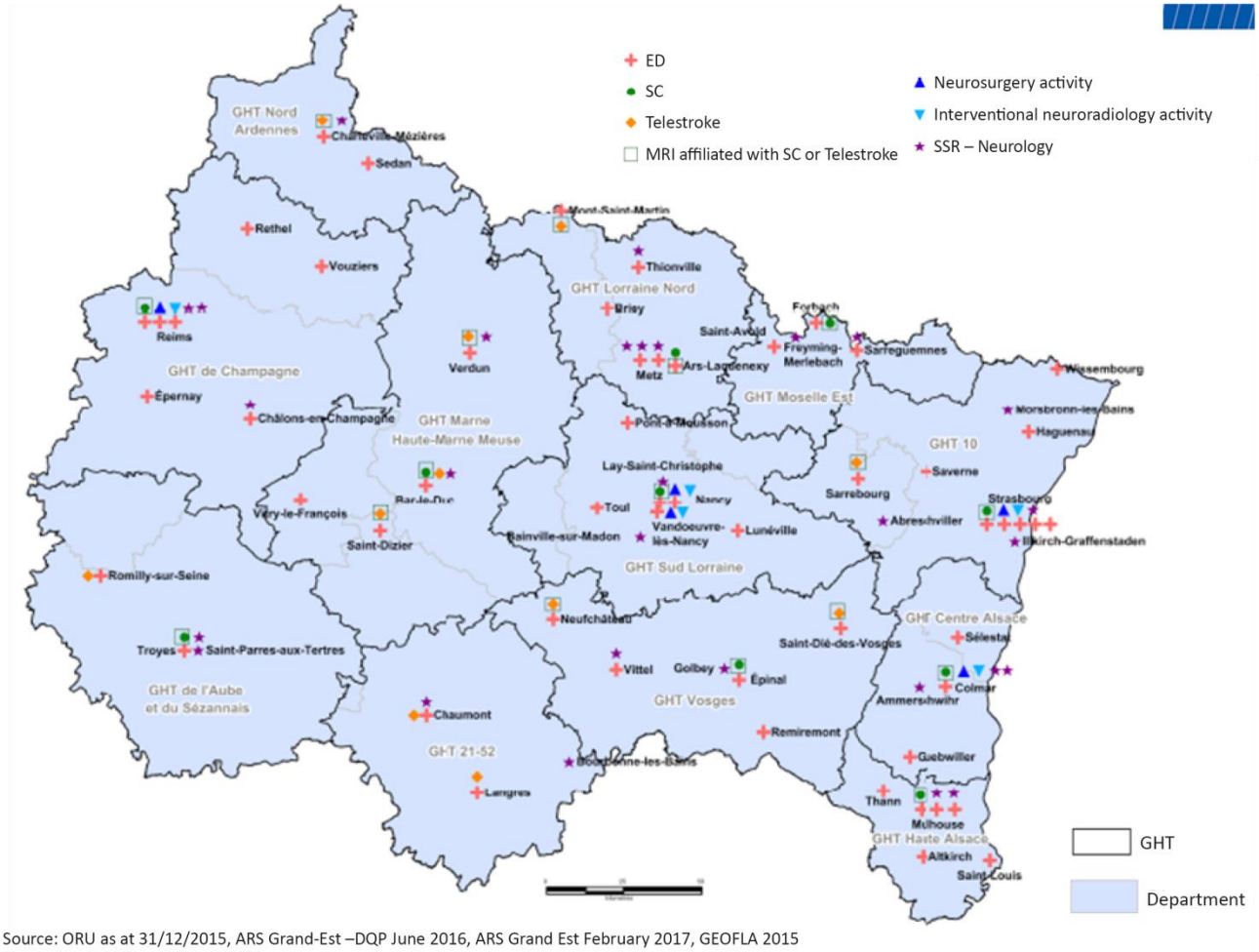
The telestroke scheme between Lannion and St-Brieuc hospitals and between Morlaix hospital and CHU Brest has been in place since 2016 for the areas at the greatest distance from the stroke centre in terms of access time. It is in the pipeline between the CHU Rennes stroke centre and Redon hospital for 2018.

Access to thrombectomy is currently based on the "*drip and ship"* model. The departmental emergency medical service call handling unit directs the patient as quickly as possible to the nearest stroke centre of telestroke unit for evaluation and clinical decision. This involves a secondary transfer to the INR unit at CHU Rennes or Brest, when the patient is eligible for thrombectomy. An INR on-call service is in place in Rennes, but none is currently in place at CHU Brest. However, MT procedures are carried out during out-of-hours services by means of the availability of INR and interventional radiologists. There are five interventional neuroradiologists at CHU Rennes, but only one at CHU Brest (two in 11/2017), assisted by an interventional radiologist.

In terms of equipment, CHU Brest contains a suite designated for 80% INR use, and another designated for 95% interventional radiology use.

CHU Rennes contains an INR suite and an interventional vascular radiology suite. It may be difficult, during the day, to insert an emergency MT procedure into an intervention schedule. Depending on the case, the procedure may take 45 minutes or 2 hours.

### ► Grand-Est




Source: ORU as at 31/12/2015, ARS Grand-Est –DQP June 2016, ARS Grand Est February 2017, GEOFLA 2015
Processing: ARS Grand-Est - -DADS

The current organisation in the Grand-Est region, due to its recent creation, is still structured based on the model of the former regions.

Mechanical thrombectomy is performed in four centres, including three CHUs containing comprehensive stroke centres; these are:

- in Alsace, CHU Strasbourg and Colmar hospital. For CHU Strasbourg, the referral locality is the Bas-Rhin district, and for Colmar hospital, the referral locality is the Haut-Rhin district. In reality, the CHU also covers referrals for inhabitants of the Haut-Rhin district;
- in Champagne-Ardenne, the referral locality of CHU Reims is the former Champagne-Ardenne region. However, it receives patients from Soissons hospital by agreement with the Hauts-de-France regional health board;
- in Lorraine, the referral locality of CHU Nancy is the former Lorraine region.

The network is substantially different in these three localities due to their specific features (particularly medical density). The above map illustrates the current status.

The region includes one stroke centre per GHT (regional hospital group) district (except for GHT1). Telestroke is rolled out heterogeneously between the three former regions. PRS2 is in the process of being developed with a view to strengthening this network.

### 7.2.2 Regional specificities and difficulties accessing MT

#### ► Ile-de-France

According to the Ile-de-France regional health board, a study[20] on transport times shows than an increase in the number of thrombectomy-capable facilities from seven to eleven facilities (plus four in the greater metropolitan area) would improve access to MT considerably, in terms of transport delay to thrombectomy initiation for all stroke centres.

Access to the procedure poses problems in some Paris comprehensive stroke centre areas due to traffic congestion in Paris, and also low staffing levels particularly for anaesthetists and INRs.

#### ► Hauts-de-France

Hauts-de-France includes eighteen stroke centres, including two in a university hospital. The main problems are associated with distances and transporter availabilities, particularly for the former Picardy region, due to an increase in secondary patient transport for returns to general hospitals for post-thrombectomy care.

The increase in thrombectomy activity impacts admission rates and therefore stroke centre accessibility for patients receiving care in the two CHRUs with other neurovascular conditions.

As regards technical platforms, accessibility is smooth, with an option of direct access to the INR suite and an option to activate a second suite if needed. They are adjoined to a resuscitation or intensive care type monitoring unit. Nevertheless, there is a shortage of skilled medical resources (INRs and anaesthetists), and the out-of-hours services, though provided, remain very precarious.

#### ► Occitanie

The current regional coverage of mechanical thrombectomy (MT) access in the Occitanie region is satisfactory, although some primary stroke centres are located over 2 hours 30 from comprehensive stroke centres and therefore involve delays making compatibility with MT eligibility difficult. A discussion on potential changes to the regional network will shortly be launched in the context of future developments of the INR SIOS (Interregional Scheme of Healthcare Provision).

[20] No reference provided.

If, within the scope of the future studies on the SIOS, needs for new facilities authorised for INR activity are identified, the distance of these institutions and the availability of current skills (particularly neuroradiologists) will mean that it will not always be possible to meet needs.

### ► Nouvelle-Aquitaine

Access to the MT procedure in Nouvelle-Aquitaine posed problems in two, or even three, localities of the region.

For patients from South Aquitaine, particularly the Pyrénées-Atlantiques district (665,000 inhabitants, 1883 patients admitted to hospital for stroke in 2015), at a distance of more than 180 km from CHU Bordeaux, and for whom helicopter transport is not always available, a loss of opportunity is currently observed due to the increased transport time.

The regional health board issued a call for applications allowing the joint selection of two facilities: Bayonne and Pau. The same process is envisaged in 2018 in La Rochelle in Charente-Maritime (660,000 inhabitants, 1694 patients admitted to hospital for stroke in 2015), located 137 km from the CHU Poitiers comprehensive stroke centre.

In this region, in order to improve emergency care in comprehensive stroke centres, it is envisaged to identify specific resources for the interventional radiology activity (MT, and also gluteal artery, femoral artery, uterine artery embolisation, spleen, liver injury, ruptured brain aneurysm, etc.), structural and human resources (particularly in terms of neuroradiologists, anaesthetists and state-qualified anaesthesia nurses). Indeed, difficulty accessing technical platforms is currently being observed, due to an increase in scheduled activity and the disorganised nature of interventional radiology emergency departments.

One of the needs identified by institutions is that of having multidisciplinary practitioners skilled in all interventional radiology procedures. However, neurologists with MT training are not trained to conduct embolisation procedures on other organs. Further, a regional diagnostic neuroradiology service project is currently in progress.

### ► Burgundy-Franche-Comté

#### Burgundy

For Burgundy, no difficulties have been reported for accessing MT which appears to meet national targets based on the following criteria:

- one MT for two fibrinolysis cases;
- a stable, skilled INR team made up of four senior members;
- an NICU unit and a neurotrauma ICU department;
- a telestroke network enabling the most exhaustive regional screening possible by means of a close-knot regional network (nineteen general hospitals linked with the CHU Dijon NICU);
- a long-standing, experienced, stable and validated Burgundy-Stroke care network;
- three helicopters prioritised for stroke cases and MT;
- six-month multidisciplinary follow-up and remote follow-up by the four nurse clinicians from the Burgundy-Stroke network.

This multidisciplinary regional network also makes it possible to respond to other vascular (brain and meningeal haemorrhages) and non-vascular (TC, epilepsy, coma, tetraplegia, etc.) emergencies presenting at the nineteen facilities.

Despite a somewhat positive review, there is scope for improvement in some stages of this pathway identified in day-to-day services and during medical training sessions; these are:

- coverage of the comprehensive stroke centre referral area: Burgundy-SHM (Sud-Haut-Marnais) covers an area as large as Belgium, and the population is relatively dense in rural areas, which poses a real problem in terms of road transport times liable to explain transfer de-

lays penalising the patient (Nevers is 2 hours 30 from Dijon by road, Sens 2 hours 45). The three helicopters reach full capacity very quickly;

- human resources:
  - very high turnover of emergency physicians, such that the level of expertise is variable among the nineteen general hospitals of the network,
  - need for proper continuous training in the nineteen facilities, by the neurovascular team based in Dijon,
  - very high turnover of radiologists, which poses problems in terms of quality of the brain and vascular imaging procedures and is liable to disrupt MT indication screening. This problem is bypassed by transferring to Dijon as a precaution, which may sometimes be inappropriate;
- technical platform availability:
  - there is no problem accessing the INR suite at CHU Dijon,
  - However, an INR staffing problem arises with the four senior practitioners potentially reaching full capacity, at over 140 MT cases per year,
  - in particular, there is an indisputable lack of NICU unit in Burgundy-SHM (Sud-Haut-Marnais), as the two current units (CHU Dijon and Chalon hospital) are finding it difficult to attend to all stroke cases; a first solution adopted is to increase the current capacity of the CHU Dijon NICU unit from ten to fourteen beds with a proportional increase of the stroke centre; a second solution consists of setting up one NICU unit at Nevers hospital and one at Sens hospital, but this solution currently appears to be complicated, due to neurological recruitment problems,
  - there is a problem in respect of the management of stroke cases on DOAC therapy, as, while CHU Dijon has the required expertise, a number of other facilities are encountering DOAC assay and reversal problems.

### Franche-Comté

The difficulties are associated with the precarious nature of the INR teams (staff shortages, highly concentrated activity, etc.) and access time to the INR platform for patients admitted to local centres.

The regional specificities explaining the access problems stem from the existence of:

- a single comprehensive centre with INR capability;
- a mountainous area with significant use of helicopter transport, but with weather-related and availability constraints;
- a low number of neuroradiologists (three-four, sometimes less);
- satisfactory accessibility of anaesthetists (specific rota and on-call system reorganisation);
- two INR suites (sufficient quality);
- a comprehensive NICU unit with ten beds (insufficient capacity for the geographic sector). Difficulties ensuring cohesion of primary-secondary transfers to the comprehensive centre.

### ► Centre-Val-de-Loire

In the Centre-Val-de-Loire (CVL) region, access to the MT procedure poses the following problems:

- problems in relation to the stroke centre coverage area:
  - outside Indre-et-Loire, the difficulties are distance-dependent, particularly as the helicopter does not fly in adverse weather conditions and flies to a variable degree at night, which poses availability problems. Moreover, the helicopter lands in Tours at Trousseau hospital, while MT is performed at Bretonneau hospital, located in the centre of Tours, giving rise to an extra travel time of 20 to 30 min,
  - the travel times (excluding waiting for the carrier) are between 30 and 40 min by helicopter, to which it is necessary to add the half-hour of transfer by road from Trousseau to Bretonneau;
- problems in relation to the number of medical practitioners with MT training:
  - for the sole INR team in the CVL region, for some of 2017, there were three practitioners on the on-call list, which led to CHU Tours to deny requests for MT procedures from other departments,

such 37 and 41, and to redirect certain patients outside the region. The recent recruitment of two practitioners, one of whom is in training, has helped remedy this problem;

- problems in relation to the number of suites available at CHU Tours:
  - the neuroradiology department only has one interventional suite, and some mechanical thrombectomy procedures cannot be performed when other urgent procedures are in progress;
- problems accessing the CHU Tours neurointensive care unit (NICU):
  - in September 2017, at CHU Tours, 145 intravenous thrombolysis procedures and 125 mechanical thrombectomies were carried out, which is equivalent to 15% and 12% of the patients admitted to the NICU unit, respectively,
  - the NICU unit includes eight beds, of which one to two beds need to be continuously vacant to accommodate patients for urgent thrombolysis or MT. It is sometimes difficult to keep this bed vacant. Indeed, growth in MT has led to the refusal of an increasing number of "conventional" patients, not requiring specific therapies,
  - it may also arise that no beds are available in the NICU unit to accommodate a patient for whom MT is indicated, which requires last-minute cooperation with the medical resuscitation unit, located in another building,
  - NICU bed resources should be designed to meet the rapid rise in demand for MT procedures, and, at the present time, patients requiring technical procedures are being preferentially directed at the expense of other stroke patients;
- problems in relation to regional emergency physician staffing shortages:
  - the precarious nature of these teams and the high turnover of practitioners complicate the implementation of a long-term training and cooperation policy. Moreover, a number of institutions have problems having sufficient neurologist teams to provide 24/7 continuity of care.

### ► Auvergne-Rhône-Alpes

Access to the MT procedure poses problems for remote or mountainous areas. 24-hour availability is lacking for the CHU Grenoble INR team. Nevertheless, helicopter availability and the border location allows for patients to receive care in Geneva; therefore, there is no actual shortage.

### ► Brittany

A study conducted in 2016[21] in the CHU Rennes INR unit demonstrated that:

- fifty percent of patients are treated during out-of-hours service times. This implies an on-call INR team (neuroradiologist, MARS);
- forty-six percent of MT procedures in the facility are performed on patients dispatched directly to CHU Rennes and exhibit shorter times between the first symptoms and clearance than for patients outside the CHU (3 hours 58 for patients at CHU Rennes and 6 hours for patients outside the CHU).

The problems in Brittany stem from the following factors:

- a small but nonetheless remote island population: stroke detection requires the most expeditious transfer to the stroke centre; thrombolysis is not available on the islands;
- medicalised secondary transfer implementation and delay problems from the stroke centre to the comprehensive stroke centre which give rise to inequalities of access to MT;
- the capacity of the CHU Rennes stroke centre is insufficient for its referral duties. Extension of the capacity is scheduled for late 2018;
- the number of interventional neuroradiologists is insufficient at CHU Brest to provide year-round 24-hour services. This is handed over to CHU Rennes. An improvement is expected with a new INR unit in Brest in November 2017;

[21] No reference specified.

- the low availability of medical anaesthetists during put-of-hours service[22] times at CHU Brest (the INR unit contacts the general theatre on-call medical anaesthetist). In Rennes, a MARS team is currently assigned to the emergency theatre and available. However, in the medium-term, the MARS demographic may burden MT procedures;
- the availability of designated IR suites may pose problems during the daytime, as the MT procedure will disrupt the interventional radiology schedule. These problems should increase with the growth of interventional radiology, including INR. CHU Brest plans to group the interventional suites on the same technical platform to boost medium-term efficiency.

### ► Normandy

Access to the procedure poses problems in terms of delays, distances, and staffing shortages (interventional radiologists and neurologists).

The problems identified in the region are:

- INR numbers during on-call period;
- lack of schedule and agreement between the two facilities, which are in the process of being drafted for the region;
- existence of frequent technical incidents in respect of telemedicine image sharing (currently under assessment by GCS TELE SANTE);
- transport to INR units;
- problem of delay in financial cover and pricing scale of returns from stroke centres (to be reported to CPAM health insurance fund).

### ► Grand-Est

Access to this procedure continues to be very mixed in the region and depends on the following factors:

- availability of adequate staff and technical platform;
- the geographic location of the patient is the source of significant regional disparities. This is demonstrated by the volumes of activity:
  - CHU Strasbourg: in 2015, 60 procedures (with resumption of activity mid-year); in 2016, 119 procedures, and in 2017, 140 procedures[23]; the long-term prospects are 180 to 200 procedures per year,
  - Colmar hospital: January to September 2017, 35 thrombolysis procedures were performed,
  - CHU Reims: 80 MT procedures in 2016, and in the first quarter (Q1) of 2017, the number of procedures doubled compared to Q1 2016,
  - CHU Nancy: in 2016, 100 MT procedures were performed, and for 2017, at least 150 procedures are expected;
- the number of surgery suites per centre: a single vascular surgery suite is available at CHU Reims and Strasbourg. CHU Nancy recently opened its second suite. An additional suite is planned at CHU Reims in the building schedule (but not for another five years at least…), but it is located at a distance from the MRI unit. Internal adjustment discussions at the hospital are in progress;
- the demographic precariousness to guarantee 24-hour activity, half of which is carried out during out-of-hours service times (night and weekend):
  - CHU Reims: the team has been rebuilt and is almost complete: one university professor-hospital practitioner, two hospital practitioners, one registrar, one additional hospital practitioner from November 2017,
  - CHU Nancy: the team is made up of four practitioners and it is planned to include one additional hospital practitioner,

[22] Out-of-hours service – known as PDSES.

[23] At the time of feedback from the regional health board.

- Colmar hospital: the team is made up of two hospital practitioners and two junior doctors,
- CHU Strasbourg: the team is made up of one university professor-hospital practitioner, two hospital practitioners, one assistant registrar, two junior doctors (one intern and one post-graduate). Three senior doctors with issue of sustainability of other positions.

The regional problems identified in the Grand-Est region are:

- a number of patients treated in the region lower than it should be;
- a population catchment area hence needing a review;
- for Lorraine, the patients received go outside the region and some arrive too late;
- the target is 24/100,000 inhabitants/year.

#### ► French Guiana

In French Guiana, access to MT is not available as there is currently no stroke centre; the project is under way with Cayenne hospital.

#### ► Indian Ocean overseas territory

The main factors capable of explaining problems accessing MT in the Indian Ocean are as follows:

- regional coverage:
  - Reunion Island and Mayotte are located at a distance of two hours by air with a single daily turnaround. Therefore, referral for MT is not possible for the population of Mayotte,
  - Reunion Island is a mountainous region, with a road network that is saturated on the coast and restricted in upper areas. Traffic problems are increased during the wet season, involving potential road closures (rock slides, submerged foundations),
  - on the other hand, the four-pole positioning of the EDs-mobile medical units enables 90% of patients to have access to emergency care (benefit in cases of IVT). The missed population represents 10%. Secondary transfers remains a significant problem, due to lack of team availability, delaying treatment in the reference centre,
  - Reunion Island should be equipped with a mobile helicopter medical service by the end of 2018 which will only operate in the daytime;
- human resources:
  - despite clear staff shortages, a 24/7 response has been provided to date by highly motivated practitioners, who are close to exhaustion. Recruitment is in progress to consolidate the team,
  - anaesthetist: a designated on-call service has been in place since 2016;
- technical platform availability:
  - direct INR suite access with a second suite available. The CHU Sud stroke centre is the reference stroke centre for the South-West stroke services and the comprehensive stroke centre for neurosurgery (on a regional level) and INR (on a regional level). Its access capacity is currently insufficient to meet the needs of the South-West services. Extension of the premises has been announced, but may be delayed due to the plan to restore financial equilibrium initiated by the CHU;
- other factors:
  - interfacility transfer time criterion: there is scope for improvement in transfer organisation, in both administrative (patient pre-admission) and medical terms. The conditions and procedure for contacting the various parties involved needs to be improved, as does the transmission of medical details for anaesthetic management.

### 7.2.3 Challenges in respect of optimal roll-out

#### ► Ile-de-France

According to the Ile-de-France regional health board, as the number of stroke cases is on the rise, particularly in young people, the number of MT procedures can only increase. The organisation with the seven INR centres is working, MT has helped improve the operation of services in a local setting.

The organisation of a work group by the Ile-de-France regional health board, with the experts and professionals involved meeting as of 2015, has led to the publication of a regional framework document in 2016[24] and to a call for applications for the organisation of the thrombectomy out-of-hours service. The purpose of this framework document is to define the contractual commitments governing healthcare institutions providing care for patients presenting with brain infarction and requiring emergency MT (mechanical clot retrieval from the cerebral arteries) in Ile-de-France.

The regional health board has also set up a registry to record all MT reviews for the region: 3.4 reviews per 24 hours; 3.2 arteriography procedures per 24 hours. Sixty percent of activity takes place during the week during out-of-hours service times or at the weekend.

In terms of human resources, problems for interventional neuroradiologists and anaesthetists have been identified; hence, the set-up of two out-of-hours services each day: one for the North of the region and one for the South.

### ► Hauts-de-France

According to the Hauts-de-France regional health board, the roll-out of the procedure has encountered information system issues due to:

- the ramp-up of the telemedicine scheme with no initial discussion on the implementation of a robust activity monitoring system;
- the preexistence in both former regions of separate information systems (host, healthcare flows, TLM record, platform, etc.) and the need, following the merging of both regions, to achieve cohesion in medical practices and activity monitoring;
- uncertainties in respect of the outcome of projects on a technical level, in a context of changing IT project management support provider, IS (GHT) cohesion being sought by institutions, merging/reassignment of some project managers;
- telemedicine procedure billing capability that has not been fixed on a national and regional level.

In both former regions, the thrombolysis and MT activity has been on the rise in recent years - these two factors indicating that demand for MT procedures will continue to grow in the years to come for the following reasons:

- the observation that an increasing number of patients are treated with direct oral anticoagulants (DOACs), and the fact that, in most cases, this treatment currently contraindicates the thrombolysis procedure, but not MT (after the thorough application of a specific protocol);
- discussions in progress in learned societies on extending times to treatment under certain conditions.

In view of this situation, the Hauts-de-France regional health board is to steer a work group on the feasibility of setting up one or more cerebral reperfusion platform(s) based on the Nouvelle-Aquitaine region model, proposed by the team at CHU Bordeaux in concert with the regional health board, given that, at the present time, the medical demographic will not enable the creation of a new centre, even outside out-of-hours service times.

Human resources for 2020/2022 (staffing required to provide a 24/7 on-call service): 105 INRs to be trained over three to five years.

### ► Occitanie

According to the Occitanie regional health board, the region is in the midst of strong demographic growth - the population is predicted to increase by over 20% by 2040. This projected growth is coupled with the significant problem of ageing of the population, since in 2040, 28% of inhabitants would be aged 65 years or over (as opposed to 20% in mainland France). These demographic

[24] AAC-cahier-charges-regional-thrombectomie, ARS Ile-De-France.

projections suggest an increase in the number of stroke cases and referral of the population to designated stroke management facilities.

In parallel with this observation, it should be pointed out that the Occitanie region faces a medical demographic problem. At the present time, some stroke centres lack medical professionals (neurologists, radiologists, interventional radiologists) to operate satisfactorily and provide patient care under optimal conditions. Some institutions will see some retirements in the years to come, with uncertainty regarding their replacements.

MT referral is still at insufficient levels in the region, in spite of healthcare professional training and awareness-raising campaigns.

### ► Nouvelle-Aquitaine

According to the Nouvelle-Aquitaine regional health board, roll-out requires prior training of professionals giving rise to a long enough delay before new centres can be opened (two years between response to call for applications, commencement of interventional radiologist training and the effective launch of MT centres in the Bayonne and Pau stroke centres).

Training of three qualified medical practitioners per centre requires a combination of an initial training process through the creation of two shared assistant positions operational in two years (one for Pau hospital and one for Bayonne hospital) and a CME process enabling hospital practitioners with IR expertise in their position for over five years (two for Pau hospital and two for Bayonne hospital) to acquire this MT expertise over two years at a frequency of one week per month. It should be specified that this CME process is aimed at practitioners with prior IR expertise and prior expertise in CT and MRI stroke management in their respective stroke centres.

An agreement is in place between CHU Bordeaux and Pau and Bayonne hospitals with a view to training non-INR practitioners and guide them (under supervision) during the first year after opening the unit. This guidance could be provided with support from the CHU Bordeaux INR department (video guidance, initial physical presence).

This roll-out is envisaged in Pau and Bayonne which have a neurosurgery department and, at a later date, in one facility (La Rochelle) with no neurosurgery platform, which could be made up for by an agreement with CHU Poitiers.

### ► Burgundy-Franche-Comté

According to the Burgundy-Franche-Comté regional health board, the challenges in respect of roll-out for these two regions are different in nature.

#### Burgundy

The INOVELAN TLM platform is characterised in Burgundy by:

- a close-knit network of nineteen general hospitals working directly with the CHU Dijon NICU unit;
- ongoing training on the ergonomic features of the TLM system;
- 24-hour effective remote support;
- effective maintenance;
- multidisciplinary roll-out based on the stroke model, to neuro-oncology and neuro-traumatology, diagnostic neuroradiology, cardiology, oncology, dermatology, psychiatry, and gerontology.

Discussions on the organisation and challenges of roll-out arise in terms of:

- growth in the population's needs: the Dijon stroke registry was the first in France to show the significant progressive increase in the number of stroke cases and to notify the supervisory authorities. Ageing of the population and the increase in the number of stroke cases in young people aged under 55 years are the causes of this, without forgetting the merger with the SHM (Sud-Haut-Marnais) region. The appropriate response is the increase in capacity of the CHU

Dijon NICU unit from ten to fourteen beds, and the opening of an NICU unit in Nevers and Sens hospitals;

- increase in MT activity: this increase linked with enhanced MT screening, the addition of the SHM region and the need to care for MT cases at CHU Besançon with INR staffing shortages, it is necessary to envisage reinforcing the team of vascular neurologists with an additional hospital practitioner for the fourteen-bed NICU, and an additional INR hospital practitioner (training of neurology intern on INR);
- impact on the regional network: with nineteen telestroke-capable facilities, the network is in line with the GHT reform as it recently included the three general hospitals in the SHM region (Langres, Chaumont and Bourbonne-les-Bains);
- adequacy of human resources: one extra hospital practitioner for vascular neurology and for INR;
- the telestroke network in the stroke pathway already offers remote consultation, remote assessment, remote support capability with junior or less experienced emergency physicians, and offers remote monitoring with stroke cases in Nevers and Sens.

### Franche-Comté

No major problems were encountered during the roll-out phase, but the activity is closely dependent on the number of INRs and the current situation is strained due to their low number.

There is a likely restriction of autonomy of the INR activity in the CHU Besançon comprehensive centre. However, there are prospects for pooling with the CHU Dijon comprehensive centre, where the TLM activity has been optimised for a number of years with a mature network.

### ► Centre-Val-de-Loire

According to the Centre-Val-de-Loire regional health board, due to the MT issue which requires a regional discussion, and also inherent medical staffing problems (emergency physicians, neurologists, INRs), it has been envisaged to set up a new regional technical committee for stroke, and extend funding for the service facilitators by at least two years. This group, which met for the first time in October 2017, was commissioned to prioritise the topics to be covered in relation to stroke management, with support from the service facilitators.

- Projected growth of MT activity:
  - need for national guidelines and benchmarking with standardised referral rates for each department. With regard to the dispatch of patients from the region, the CHU Tours production data are insufficient to compare referral rates;
  - besides changes arising from progressive trends observed in recent years, the projection should account for the possible extensions of times to treatment.
- Impact on regional network:
  - need to consolidate and harmonise regional stroke management services, despite inherent medical staffing problems in the CVL region (emergency physicians, neurologist, radiologists). A study is required to review the location of telestroke-capable emergency facilities, as well as links between telestroke, stroke centre and MT facilities, so as to enable triangulation beyond the current point-to-point model;
  - query on the suitability of individualised MT provision in Orléans to limit travel times: however, this hypothetical case would lead to a dispersion of resources in respect of trained practitioners who are currently rare, and therefore raises the question of trained practitioner staffing levels.
- Ensuring adequacy of human resources to cover daytime activity, on-call service, out-of-hours service and continuity of care:
  - prioritise consolidation of the CHU Tours team, the sole facility authorised for INR activity, to safeguard the existing status, accounting for:
    - continuous access to an MT procedure;
    - access to MRI;

  - stroke centre capacity which is liable to be insufficient due to admission of regional patients for MT.

- Telestroke project in the care pathway (remote consultation, remote assessment, remote medical support and remote medical monitoring):
  - with the exception of emergency care, telestroke is not being developed in other areas of stroke management.

### ► Auvergne-Rhône-Alpes

According to the Auvergne-Rhône-Alpes regional health board, to promote MT development, the limiting factor is team availability for organisation and continuity.

This region has the specific feature of being a border area, which is to be enhanced with Geneva.

The appeal of INR could be increased, both through the number of team members and the valuation of night-time working hours.

### ► Brittany

According to the Brittany regional health board, procedure roll-out problems are not specific to the region and are as follows:

- the lack of valuation in the T2A model of MT admissions which may have acted as an obstacle to investment by institutions, in a tight budget context. In Rennes, the Brittany regional health board provided financial support for two years for the creation of a 4th INR hospital practitioner position to consolidate the team over the long term;
- initial INR resources: the INR in Brest has only been in the position since the summer of 2015, and a 2nd INR arrived in November 2017;
- the radial organisation centred on eight stroke centres and telestroke promotes access to thrombolysis for everyone, but requires interfacility secondary transfers, thereby prolonging times to MT treatment;
- the limited capacity resources of the stroke centre and the NICUs in the main INR facility serving three departments, also represent an obstacle to MT development;
- traceability problems in respect of this activity.

Improving emergency stroke management has been included in the next regional healthcare plan, targeting priority areas. The RBU (Brittany emergency department network) CPOM contract has included improving access to MT as a priority.

- Needs: if the needs are estimated at between 4% and 10% of ischaemic stroke cases, in Brittany, the number of MT procedures to be carried out for Breton patients would be between 250 and 650. In 2016, Brittany found itself at the lower limit of regional inequalities - there is scope for further progress.
- Growth: no projected figures are available on MT activity growth, the aim is to increase activity while limiting inequalities of access and have discussions with all of the stakeholders on a more effective organisation, and also promote calling the 15 advice line immediately with the general public in order to reduce delays.
- Network: no projections in respect of modifications of the regional network are available, but a discussion is needed on the emergency pathway following stroke detection, on prehospital stroke call handling, and on the first-line dispatch to the stroke centre or comprehensive stroke centre. Further discussions are also needed on medicalisation of secondary transfer for MT and on carrier availability.
- Human resources: it will be necessary to consolidate teams in INR units, particularly the team in Brest which remains precarious, increase availability of medical anaesthetists, and consolidate teams in stroke centres downstream from MT.
- Telestroke: it will be necessary to consolidate the telestroke scheme in capable facilities, and extend the range of hours. CHU Rennes has a telestroke extension project with the three peripheral hospitals in the district, with emergency departments.

- A trial is being conducted within the scope of an MT research project in the Vannes facility (Vannes is not an INR facility) by the interventional radiologists, with remote INR support. It commenced in March 2017; currently, the IRs were trained by the CHU Rennes INR, they carry out MT in Vannes hospital with remote support from an INR based at CHU Rennes, and with the presence of another INR in the suite at Vannes hospital as the trial is in the initial stages. The aim is to roll out the practice to voluntary interventional radiologists, trained with remote support via smart glasses, and increase accessibility to the procedure.

### ► Normandy

According to the Normandy regional health board,

- a communication campaign on the need to call the 15 advice line is currently being rolled out, this will enable a better assessment of the population's needs, and also of the growth in demand;
- growth in MT activity is predicted;
- some localities, with high risk factors, have a shortage of medical resources; this could impede the roll-out of new primary stroke centres to meet needs;
- in terms of the adequacy of human resources to cover daytime activity, on-call services, out-of-hours services and continuity of care, the appeal of the Normandy region for medical human resources is currently being worked on in the Normandy regional healthcare scheme;
- as regards the telestroke project in the care pathway (remote consultation, remote assessment, remote medical support and remote medical monitoring), the care pathway implemented in the region now includes all aspects of the telestroke scheme.

### ► Grand-Est

According to the Grand-Est regional health board, neuroradiologists have generally taken up the extra activity; however, there is little visibility in terms of growth projections of the activity (with regard to the population's actual needs), even though recent studies appear to indicate quasi-systematic indication of MT in addition to IVT. For all that, the region's PRS2 plan states the need to include this therapeutic regimen in prehospital triage procedures.

- The MT centre network does not need to be modified. Neuroradiologists are campaigning not to increase the number of centres, particularly in view of medical demographic problems. For all that, discussions are needed in relation to the Colmar centre which is encountering problems covering patient care, particularly at out-of-hours service times.
- MRI access: MRI is the best assessment method. This is where a bottleneck may occur = MRI access within the first 24 hours.
- Modes of transportation: improve organisation. In some cases, neuroradiologists are not contacted, as management commences too late.
- Adequacy of human resources: the ideal situation would be to have five to six practitioners to guarantee 24-hour presence and sufficient activity to maintain skills.

### ► French Guiana

According to the French Guiana regional health board, it will be necessary to reinforce the set-up or roll-out of the telestroke scheme with CHU Besançon. There are no medium-term prospects to implement MT at the present time.

### ► Indian Ocean overseas territory

According to the regional health board of the Indian Ocean overseas territory, the recognised role of MT in stroke management has been welcomed and has not given rise to hesitancy on the part of neurologists and emergency physicians. Reimbursement of the MT procedure provides relief in the financial context of the institution.

Simulation software was funded in late 2016 by the regional health board in order to develop skills locally and promote uptake in-house staff, but the model initially envisaged would not be sufficient.

The technical solutions to facilitate the use of the telestroke scheme will most likely incur an additional cost for institutions that have already been financially impacted, which may impede roll-out and use.

- The projected growth in MT activity (based on European statistics) would be 80 to 100 MT procedures annually for the population of Reunion Island, which may increase in future years, in view of the ageing of the population and the prevalence of type 2 diabetes.

As regards ensuring the adequacy of human resources to cover daytime activity, on-call services, out-of-hours services and continuity of care, which currently represents the main weak point for an optimal roll-out, the recruitment of one or two further interventional neuroradiologists will make it possible to treat stroke cases requiring mechanical thrombectomy, the restoration of the theoretical staffing level (seven FTE) of the neuroradiology department (envisaged in early 2018) will thus help partially separate diagnostic activity from neurointerventional activity, and improve the quality of care.

- Telestroke project in the care pathway (remote consultation, remote assessment, remote medical support and remote medical monitoring): the roll-out of the remote assessment scheme should be operational in all services no later than 2018. Remote consultation has not been recognised as a priority of use, but peripheral EDs are provided with this capability to address specific scenarios, or scenarios other than acute stroke. A draft telestroke usage agreement between institutions has been proposed. The compensation paid by requesting institutions to referral or expert institutions may impede the use of the telestroke scheme.

No plan for use in the context of remote medical support or medical monitoring.

## 7.3 Establishment of resources enabling access to emergency care in less than 30 minutes

These include emergency departments, mobile medical units, mobile medical unit offices, if applicable, EMS medical contacts (MCS), mobile helicopter medical units, and national security helicopters. Access by the population to emergency care in less than 30 minutes is one of the government's priorities. This target was one of the commitments in the Regional healthcare agreement (PTS) 1 and was renewed within the framework of PTS2.

No data have been made available to date by DGOS (73).

## 7.4 SFNR survey: overview of INR units in France

The aim of the SFNR survey conducted in January 2016 was to obtain an overview of interventional neuroradiology (INR) units in France. These interventional neuroradiology (INR) units are affiliated with reference stroke centres that can receive patients directly or via primary stroke centres.

### 7.4.1 Materials and methods

Thirty-eight centres authorised to practise INR by regional health boards were surveyed in March 2015 by means of a questionnaire and aimed at:

- counting the number of qualified and trainee neuroradiologists;
- detailing the geographic distance of the INR units affiliated with a reference stroke centre from the 95 local stroke centres identified;
- detailing the number of MT procedures performed in 2014.

The survey data were updated in January 2018.

### 7.4.2 Survey findings

The findings of this survey were represented using an interactive map (*cf.* SFNR website (74)).

### ► In terms of care provision

Thirty-seven interventional neuroradiology centres actually practised MT in France in 2015.

### ► In terms of MT activity

Four thousand six hundred procedures were performed in 2016, and 5700 are estimated for 2017, which represents an estimated increase in activity of over 20% between 2016 and 2017; it was more than 140% between 2014 and 2015, and more than 57% between 2015 and 2016.

The 2018 update shows a growth in MT activity: 5591 MT cases in 2017, i.e. fifteen MT cases per day. Regional disparities in terms of overall increase, varying according to the centres, are observed:

- < 50 MT cases three units;
- 50-100 MT cases twelve units;
- 100-200 MT cases eleven units;
- 200-300 MT cases six units;
- > 300 MT cases four units.

The MT activity is broken down into daytime and night-time activity, 25% in the middle of the night (12-6 a.m.), and 35% at weekends.

### ► In terms of medical demographic

This MT activity is covered by 109 senior physicians, and 28 physicians are in training (creation of 20 INR training positions planned in 2018, and 51 assistant registrars in INR training). The out-of-hours service is covered by 131 on-call physicians, i.e. approximately 3.5 per centre with disparities of one to five; each practitioner performs on average 43 MT procedures.

### ► In terms of access to care

The average distance of INR centres from primary stroke centres is 83±53 km. This distance is usually covered by road (72% of centres) or by helicopter (28%). The estimated transfer times are less than 30 minutes (14.7% of centres), 30 to 45 minutes (16.8%), 45 to 60 minutes (33.7%), 60 to 90 minutes (29.5%), and more than 90 minutes (5.3%). In these units, 1216 MT procedures were performed in 2014, i.e. 11.7 MT procedures per qualified neuroradiologist. The survey did not distinguish between the proportions of patients dispatched by the reference stroke centre affiliated with the INR unit and those dispatched by a local stroke centre.

## 7.5 COPIL position on care provision in France

In the view of SFNR, the overview of care provision is essential to move forward. However, it does not reflect the work carried out by the interventional neuroradiology unit that perform these MT procedures and treat patients in conjunction with vascular neurologists: the number of MT cases doubled between 2015 (2800) and 2017 (5600), and the target of 8000 MT cases seems to be achievable.

SFMU points out the incomplete assessment of the feasibility of referrals to comprehensive centres.

All of the stakeholders state that the overview of care provision is relatively comprehensive overall in their view, but note however the heterogeneity of care and provision depending on the regions, which highlights the importance of a regional and inter-regional discussion.

For all of the stakeholders (neuroradiologists and neurovascular specialists), we need to use the existing set-up as a basis, i.e. 139 stroke centres in France, and organise MT around these stroke centres. It will also be necessary to reinforce the teams at the 37 INR units which currently represent the main network. SFNR also points out that some centres do not have the optimal medical staffing of four interventional neuroradiologists to cover out-of-hours services, hence the need for

reinforcement. In the view of SFNV, this reinforcement should also apply to 24-hour access to adequate imaging, and also stroke centre capacities which should, if needed, be increased to meet demand. These stakeholders therefore propose that the roll-out strategy in respect of stroke centre-supported MT centres be conducted in two phases, prioritising enabling proper operation of existing INR units (comprehensive stroke centre), followed by, in the view of SFNV, a roll-out to some primary stroke centres with high recruitment levels, which do not have excessively long travel times to the comprehensive stroke centre. This transport time is a subject of debate: it should be between 1 hour and 1 hour 30. SFNR states, for its part, that the creation of a new unit needs to meet regional needs based on accurate data such as the distance from the comprehensive INR unit (over 90 minutes), minimum number of potential MT procedures based on the population catchment area, and the number of IV thrombolysis procedures carried out; the creation of new units in healthcare institutions previously granted an authorisation for cranial neurosurgery and including a stroke centre should be prioritised.

In the view of SFNR, the new MT centres should ideally be INR units practising not only MT, but also other INR procedures, which would facilitate attracting and maintaining interventionalists' technical expertise and the minimum activity threshold.

The alternative would be create units only practising MT, but these centres must provide a 24/7 out-of-hours service, requiring the presence of three to four skilled interventionalists, and must meet the criteria set out above.

**Findings on the overview of MT-related care provision in France and roll-out challenges**

**Interregional Schemes of Healthcare Organisation**

- The aim of the Interregional Schemes of Healthcare Organisation (SIOS) is to optimise the response to healthcare needs by ensuring synergy of expertise while retaining a good degree of accessibility to care provision for the areas concerned, including interventional neuroradiology. These aspects are therefore defined in principle by the regional health boards (ARS). Cerebral vascular accidents (CVA, or stroke) are one of the main conditions treated using INR.
- All of the SIOS documents analysed agree and highlight the prospect of MT development which represents a challenge for interventional neuroradiology teams. This activity requires the shortest possible time to treatment after the onset of stroke (six hours) and therefore 24-hour availability of a medical and paramedical team. According to the SIOS schemes, the potentially foreseeable increase in MT procedures is driving growth in interventional neuroradiology teams and general anaesthesia teams (for a portion of these procedures).
- Each region must organise the neurovascular services for its own locality. Harmonious development of interregional telemedicine (telestroke) in terms of interventional neuroradiology activities will particularly make it possible to envisage sharing expertise (telemedicine) between INR units, based on models to be defined with the stakeholders concerned.

**Regional organisation of neurovascular services**

- The SFNR survey findings report an estimated increase in activity of over 20% between 2016 and 2017, with an update in 2018 demonstrating an MT activity of up to 5591 cases in 2017, i.e. fifteen MT procedures per day. Moreover, regional disparities, with nonetheless an overall increase, but varying according to the centres, are observed.

- The MT activity is broken down into daytime and night-time activity, 25% in the middle of the night, and 35% at weekends. It is covered by 109 senior practitioners, and 28 practitioners are currently in training.
- The average distance of INR units from primary stroke centres is 83±53 km. The estimated transfer times are less than 60 minutes (67.2% of centres) and more than 60 min (34.8%).
- The survey conducted on the regional health boards made it possible to describe the regional specificities causing problems accessing the procedure and identify the challenges in respect of the optimal roll-out of MT.

### Issue of accessibility of care provision and structure of services

Regional specificities, such as the area, geographic position, remote or mountainous areas, raise the question of the adequacy of the INR provision network to ensure times to treatment that are compatible with patient safety. The structure of neurovascular services (call handling, emergency department, radiology, stroke centre) enables optimal management of patients eligible for IV thrombolysis, but requires adaptation for MT:

- adapt admission capacities to the population's needs (stroke centre, ICU, post-stroke consultations, telemedicine, discharge and return home, rehabilitation);
- conduct proper regional coordination of stroke services, in a comprehensive manner, incorporating all expertise and management needs: thrombolysis and MT;
- account for the coordinated key expertise necessary for management: out-of-hours services, EMS call handling, role of emergency physicians, neurologists, neuroradiologists, teams of anaesthetists, radiologists and suitable staff (caregivers, porters, healthcare executives, etc.) for cases requiring care in tight time-frames;
- offer suitable care provision, in particular 24-hour imaging (MRI) in facilities with an ICU/stroke centre: the option to refer for MRI or CT perfusion on a 24/7 basis in MT units, with adequate staff (physicians, radiographers) and organisation, would make it possible to offer the population superior diagnostic coverage;
- continue to harmonise care: common protocols, common systems. etc.;
- develop interfacility cooperation for graduated care which helps reduce inequalities of access to care.

#### Issue of out-of-hours services

- Accessibility applies to the management of emergency cases, particularly in the context of out-of-hours services. It challenges both medical and paramedical resources and accessibility to interventional neuroradiology suites in a surgical setting. Due to the increase in MT procedures, medical staffing levels need to evolve to support needs associated with the activity and the obligation to provide out-of-hours services. Human resources are deemed to be lacking by all of the regions to be able to provide satisfactory out-of-hours services.
- At the present time, out-of-hours services, both in diagnostic terms via telemedicine and in terms of clinical procedures, must be organised in concert with the EMS who must be aware of the care provision availability on a regional scale.
- A pooling of diagnostic and interventional on-call lines is observed in some regions.

#### Issue of compliance with standards, quality and safety of care

- In the human resources section, the presence of four experienced staff members when performing an interventional neuroradiology procedure, including MT, appears to be difficult to achieve in all regional INR facilities.

- Furthermore, it is necessary to add the issue of the shortage of hospital medical anaesthetists, worsened by growth in this activity.
- Due to the increased prevalence in the future of MT indications in the treatment of ischaemic stroke cases, it will be necessary to have a second suite (biplanar or monoplanar) available in the years to come.
- Interventional neuroradiology activity should be carried out in an operating suite setting. In addition, interventional vascular neurology procedures should only be performed in the vicinity of a neurosurgical team and a stroke centre.
- A further point of which to be mindful, raised by regional health boards, relates to interventional neuroradiology team staffing and training to be able to cope with the growth in the activity without prejudicing the quality/safety of care.

**Issue of cooperation and development of information systems**

- Cooperation arrangements between institutions in a number of regions are in place. Some regional health boards note the need to continue definition and promote the development of suitable information systems.

**Issue of better valuation of INR activity, including MT**

- The valuation of MT admissions and night-time working hours could increase the appeal of INR.

# 8. Strategic guidelines

## 8.1 Supplement INR activity with MT units

In the code of practice of MT in France, SFNR recommends optimising neuroradiological activity due to the projected increase in MT cases (12).

### 8.1.1 Team optimisation

**► Code of practice of MT in France**

*"The projected increase in MT activity requires neuroradiology team reinforcement with, for each unit, the need to provide:*

- *out-of-hours services: at least four qualified interventional neuroradiologists are recommended, to be adapted to each centre's activity;*
- *contract-based, valued teleradiology in order to carry out remote assessment, or even remote diagnostic, procedures, for the various healthcare centres;*
- *a training policy with a trainee interventional neuroradiologist position (CCA, AHU, AS) for each centre and designation of an intern for this activity"* (12).

### 8.1.2 INR unit optimisation

**► Code of practice of MT in France**

As stated above, in order to meet MT availability requirements, the neuroradiology unit should have:

- access to two angiography suites, including one with immediate access, 24/7; these two suites should be suitable for carrying out MT procedures;
- a nearby 24-hour MRI-CT imaging platform (12).

### 8.1.3 Optimisation of imaging-based patient selection

**► Code of practice of MT in France**

The SFNR guidelines on MT in AIS highlight the importance of patient selection guided by clinical examination and imaging, so as to mobilise all of the healthcare resources required to carry out this procedure in a suitable and timely manner. Patient selection by the neurologist based on the clinical data and the neuroradiologist based on the imaging data makes it possible to mobilise MT stakeholders immediately, or even EMS, for urgent patient transfer, when initial care is provided at a facility at a distance from the interventional neuroradiology unit.

In the context of the selection of patients eligible for MT, the initial diagnostic imaging should rule out intracranial haemorrhage, rule out overly extensive infarction, demonstrate the existence and site of the arterial occlusion, and even estimate the ischaemic penumbra. For this, the generation of MRI and MRA, or CT or CTA, imaging data complies with specific acquisition and reconstruction protocols. The selection of the mode should make it possible to fulfil the imaging objectives as quickly as possible.

In order to set up this necessary patient selection, it is necessary to make a distinction between three different patient admission circumstances.

#### Scenario No. 1 - Admission to a facility equipped with an INR unit with a stroke centre

The neurologist and neuroradiologist are directly involved in selection with the aid of suitable clinical and imaging examinations. IVT is administered prior to transfer to the interventional neuroradiology unit for MT.

### Scenario No. 2 - Admission to a facility equipped with a stroke centre with no INR

The neurologist and neuroradiologist at the admitting facility are involved in selection by conducting suitable clinical and imaging examinations. IVT is administered. They notify the neurologist and neuroradiologist at the INR unit, who may use telemedicine and remote assessment to give their approval prior to any transfer to the interventional neuroradiology unit for MT.

### Scenario No. 3 - Admission to a facility with no stroke centre

After conducting the clinical examination and obtaining the imaging report, the emergency physician contacts the neurologist, or neuroradiologist, at the facility equipped with an INR unit and a stroke centre. In the absence of a radiologist at the admitting facility, contrast medium is injected under the responsibility and in the presence of the requesting physician. Telemedicine and teleradiology are used for patient selection. Teleradiology may be used for the purposes of remote assessment, or remote diagnosis, if no radiologist is present on-site. IVT is administered. The patient is transferred to the facility equipped with an interventional neuroradiology unit for MT.

### ► Systematic review and meta-analysis by Ryu *et al.* (2016)

The aim of this study was to assess the scientific evidence available in respect of the utility of perfusion imaging in determining the eligibility for treatment of stroke patients and in predicting clinical outcomes.

The findings of this meta-analysis indicate that perfusion imaging leads to better selection of patients who will benefit from reperfusion therapy, with up to 1.9 times the odds of achieving independent functional status at 3 months ($p<0.01$). According to this review, this is particularly important as patients selected based on perfusion status often demonstrated longer times from stroke onset and involved patients who would have traditionally been excluded from treatment based on standard eligibility criteria. As such, even in studies that treated patients with unknown or unclear stroke onset times, patients had similar outcomes compared with the control group without an increased complication rate. According to the authors, these results suggest that current treatment protocols that rely heavily on time from symptom onset may be too conservative, thereby leading to missed opportunities for additional successful treatments. Perfusion imaging may represent a complementary tool to standard radiographic assessment in enhancing patient selection for reperfusion therapy (30).

While the conclusions of this review indicated a benefit of perfusion imaging in the selection of patients eligible for endovascular therapy, U.S. and European guidelines nonetheless state that there is no evidence of its efficacy to date.

### ► *American Heart Association / American Stroke Association* (AHA/ASA) guidelines (2015 and 2018)

The benefits of additional imaging beyond CT and CTA or MRI and MRA such as CT perfusion or diffusion- and perfusion-weighted imaging for selecting patients for endovascular therapy are unknown (**class IIb, level of evidence C**).

Further randomised, controlled trials may be helpful to determine whether advanced imaging paradigms using CT perfusion, CTA, and MRI perfusion and diffusion imaging, including measures of infarct core, collateral flow status, and penumbra, are beneficial for

selecting patients for acute reperfusion therapy who are within 6 hours of symptom onset and have an ASPECTS <6 (34).

In the 2018 update of the AHA/ASA guidelines, it is specified that additional imaging beyond CT and CTA or MRI and magnetic resonance angiography (MRA) such as perfusion studies for selecting patients for mechanical thrombectomy in <6 hours is not

recommended (**class III, level of evidence B-R**) (35).

► ***European recommendations on organisation of interventional care in acute stroke* (EROICAS) (2016)**

The European recommendations pertaining to selection criteria for patients eligible for additional MT therapy compared to medical treatment alone based on imaging criteria (MRI *versus* CT) state that the additional benefit of advanced perfusion or collateral

image processing for patient selection is not established and requires further study (**quality of evidence: low, strength of recommendation: strong**) (37).

### 8.1.4 MT pathway optimisation

► **Code of practice of MT in France**

The SFNR code of practice recommends optimising the various stages of the MT pathway, with the aim of minimising patient access time to MT; this involves:

- reducing prehospital phase times, by registering the institution in the operational list of resources (ROR), and broadcasting information campaigns to encourage the population to dial 15, in cases of suspected stroke or TIA;
- dispatching the patient urgently via EMS to obtain a specialist opinion without delay (local stroke centre or emergency department), and brain imaging with a view of the intracranial vessels;
- obtaining neurovascular and neuroradiological advice on-site or by remote assessment to establish the indication of MT;
- optimising dispatch modes and times (EMS) to the INR unit once the indication of MT has been established, the aim being to be able to achieve cerebral reperfusion (end of thrombectomy) before the 6$^{th}$ hour;
- rolling out telestroke assessment and valuing the procedure in terms of pricing and medical staff recruitment;
- setting up priority "MT services" in the institution aimed at improving the flow and speed of MT implementation, with strong involvement of:
  - anaesthesia teams,
  - porter teams;
- reducing the time from patient admission to occluded artery reperfusion to less than 90 minutes;
- having a sufficient number of 24-hour beds in the stroke centre and potential access to intensive care beds (12).

► **Prehospital care of ischaemic stroke victims as per Seigel *et al*. (2017)**

The purpose of this narrative review was to highlight the recent advancements in acute ischaemic stroke diagnosis and treatment, with special attention to new features and recommendations of stroke care in the neurocritical care unit.

According to this review, the importance of the timely treatment of stroke has resulted in changes in patient assessment and, if applicable, their treatment in a prehospital setting. The roll-out of mobile stroke units has proven to be effective in terms of EMS call response, patient assessment in the field, confirmation of the absence of intracranial haemorrhage and intravenous tissue plasminogen activator (IV tPA) administration prior to admission. However, this scheme may require an initial investment and is not currently financially feasible for most medical emergency departments or municipalities. An alternative to mobile stroke units would be to upgrade the current ambulance fleet using telemedicine and telestroke technology. Neurologists can assess patients in an ambulance prior to their arrival at the hospital via secure audio/video platforms. By assessing patients en route, the neurologists can obtain an NIHSS (*National Institutes of Health Stroke*) score and, if possible, assess the patient for any criteria ruling out tPA. Once the patient arrives at the emergency department, laboratory tests and a non-contrast brain CT scan are obtained without delay. If

the NIHSS score is sufficiently high to envisage endovascular therapy, using tPA, the appropriate admitting hospital staff are mobilised immediately with a view to a potential IV procedure prior to the patient's arrival (75).

### ► Role of prehospital triage and interhospital transfer by Mokin *et al*. (2016)

The narrative review published by the Department of Neurosurgery of the University of Buffalo in the USA examined the key results of trials and recent updated guidelines. It discussed changes in stroke systems of care, with an emphasis on the role of prehospital stroke triage, interhospital transfer, and the two levels of stroke centre certification (primary and comprehensive).

A comprehensive stroke centre provides the highest level of care for acute stroke patients and has 24/7 access to emergent imaging (CT and MRI), IV thrombolysis, and neuroangiography, and a dedicated multidisciplinary team (stroke neurology, neurointerventional, neurosurgery, and neurocritical care teams). Comprehensive stroke centres can accept patients directly or via interhospital transfer from primary stroke centres (which can administer IV thrombolysis) or from community or rural hospitals. Telestroke works closely with comprehensive stroke centres and other hospitals to determine which patients require IV thrombolysis, endovascular thrombectomy, or both. Mobile stroke units allow administration of IV thrombolysis "in the field", with potential for bypass of primary stroke centres and transfer of those patients who are candidates for endovascular therapy directly to comprehensive stroke centres. (76).

#### Prehospital assessment of stroke patients

According to Mokin *et al.* (76), several neurological tests have been developed with the goals of offering a quick "on-site" prehospital assessment of neurological deficits and identifying those stroke patients who are likely to harbour LVO.

These tests include the Los Angeles Motor Scale, the Cincinnati Prehospital Stroke Severity Scale (CPSS), and the Rapid Arterial Occlusion Evaluation (RACE). The main advantage of such scales is their relative simplicity, allowing emergency medical personnel with different levels of training to utilise such tests as screening tools for rapid clinical assessment via the answers to two key questions: *is this patient having a stroke? and is the stroke likely from large vessel occlusion (LVO)?* Several independent studies that validated the accuracy of those three scales and other similar screening tests found that such prehospital stroke scales are (as one might expect) subject to error, with various degrees of limitations in both specificity and

sensitivity, depending on the time of stroke onset and type of stroke.

According to this review, these simple screening tests provide immediate assessment of potential stroke patients, helping ambulance officers, paramedics and other emergency personnel to identify potential candidates for endovascular therapy. Such quick examinations are not designed to serve as a substitute for imaging tests to confirm or exclude LVO but rather as screening tools to help determine the appropriate level of care (e.g., community hospital, primary stroke centre, comprehensive stroke centre) appropriate for an individual patient. Even the *National Institutes of Health Stroke Scale* (NIHSS), although much more detailed in evaluating neurological function and, therefore, more time-consuming to administer, is also prone to error when used as a predictor of LVO. The authors of the review described the findings of a study showing that an NIHSS score

of 9 in strokes with symptom onset within the first 3 hours carries an excellent predictive value (86%). However, in the same study, the NIHSS demonstrated poor predictive value for identification of LVO in posterior circulation strokes and in those patients who presented beyond the six-hour window. Therefore, a neurological examination, whether brief or detailed, cannot alone serve reliably as a marker of LVO, and a non-invasive imaging modality, such as CT angiography or magnetic resonance angiography, is needed for confirmation. The authors of the review concluded that, with more data emerging on this subject, it is becoming clear that training of prehospital providers becomes essential in ensuring that potential candidates for endovascular stroke therapy are properly recognised and triaged to neuroendovascular-equipped tertiary centres (76).

### Hospital protocols and interhospital transfers

According to Mokin *et al.,* once the potential thrombectomy therapy candidate arrives at the treating centre, any delays to establishing successful recanalisation of the occluded

vessel need to be prevented or minimised. A variety of imaging protocols currently exist, including the use of CT scanning, magnetic resonance imaging, and angiography, as well as advanced CT- or magnetic resonance-based perfusion imaging. Conflicting data exist on what is currently considered the "best" imaging modality to evaluate stroke patients. Some studies demonstrate benefits of advanced perfusion imaging, whereas other studies found the opposite, proving that such additional tests only create delays in the onset of intervention, without any added benefit. Presently, individual institutional practices range significantly in how quickly (or not)

certain imaging tests can be performed and how rapidly the results of those tests can be communicated to the multidisciplinary teams that are evaluating and triaging stroke patients. Patient transport from imaging to the neurointerventional suite (known as "*picture-to-picture time*") can be greatly reduced by early mobilisation of the anaesthesia and neurointerventional teams in parallel, rather than after the imaging is completed and a decision is made to proceed with stroke intervention. Several studies have assessed factors associated with the efficacy of interhospital transfer of a potential candidate for endovascular therapy. Use of CT angiography and endovascular treatment at the same centre was associated with shorter times to the start of intervention (76).

#### ► Predictive clinical scores according to the retrospective study by Turc *et al.* (2016)

Turc *et al*. assessed the performance of clinical scores to predict large-artery occlusion on a cohort of stroke patients admitted within six hours following symptom onset. Several scales used for clinical diagnosis and to assess the severity of acute stroke were thus assessed: CPSS, NIHSS, RACE, ROSIER (*Recognition of Stroke in the Emergency Room*) (77).

According to the findings of the study, using published cutoffs for triage would result in a loss of opportunity for ≥ 20% of patients with large-artery occlusion who would be inappropriately sent to a centre lacking neurointerventional facilities. Conversely, using cutoffs reducing the false-negative rate to 10% would result in sending almost every patient to a comprehensive stroke centre. Therefore, the authors suggest that intracranial arterial imaging should be performed in all patients with acute ischaemic stroke presenting within 6 hours of symptom onset (78).

In the MT era, several other studies have also sought to determine whether clinical scores could help identify ischaemic stroke patients with large vessel occlusion with a view to improving triage (78-81). The findings of these studies suggest that using predictive scores accounting for transport times to triage stroke patients to the nearest suitable hospital might result in the best outcomes.

## 8.2 MT activity assessment and follow-up

### 8.2.1 Registry participation

#### ► HAS recommendations (2016)

In its assessment report on endovascular intracranial artery thrombectomy, in 2016, HAS recommended setting up an exhaustive registry of patients treated using this procedure to track the spread of the procedure and obtain data in respect of use in routine practice (2).

#### ► *American Heart Association / American Stroke Association* (AHA/ASA) guidelines (2018)

According to the AHA and ASA, participation in a stroke data repository is recommended to promote consistent adherence to current treatment guidelines, to allow continuous quality improvement, and to improve patient outcomes (**class I, level of evidence B-NR**).

► **Practical guide to mechanical thrombectomy by Evans *et al*. (2017)**

This guide notes the need for international mechanical thrombectomy registries to identify whether the real-world experience is commensurate with that seen in the positive clinical trials (32).

► **Review of the implications of endovascular therapy for the organisation of stroke systems of care in North America by Smith *et al.* (2015)**

According to this review, it is recommended capturing safety outcomes in real-world practice using registries to ensure that endovascular therapy in community practice is as safe as in clinical trials, as was previously documented for alteplase. Safety outcomes include symptomatic intracranial haemorrhage and the rate of major disability at 90 days. Moreover, participation in certification programmes is strongly recommended. One component of maintenance of site certification should be participation in a registry and review of one's own performance and outcomes (31).

### 8.2.2 Peer review process

► **TJC "*The Joint Commission" guidelines***

The TJC guidelines stipulate that the hospital must have a peer review process to review and monitor care provided to ischaemic stroke patients with subarachnoid haemorraging, treated with rt-Pa. Comprehensive stroke centres performing MT procedures for IS patients with LVO should incorporate specific performance metrics in this process, associated with timely and effective endovascular therapy for these patients (see below). In addition to an internal peer review process, a national endovascular therapy performance metrics database, similar to that obtained with the registry of IV thrombolysis therapy metrics guidelines would be useful to measure quality outcomes of individual centres and identify potential measures to improve performances (49).

### 8.2.3 Indicators of quality and safety of care

The key performance indicators (KPIs) defined by HAS measure key stages throughout the stroke management process. They are used to measure and guarantee the quality of care according to its three aspects: efficacy and safety of care, access to the best care. They represent shared benchmarks of quality of care, regardless of the organisation model. KPIs apply to practices and processes making a direct contribution to clinical outcomes. As such, complementary to and on the basis of the array of stroke guidelines from learned societies and professional associations, KPIs represent tools for analysing and implementing quality of practice (45).

The main emphasis of the MR CLEAN, ESCAPE, EXTEND IA, SWIFT PRIME and REVASCAT trials (3-7) was the measurement and implementation of timely times to treatment and of an effective work process. Metrics of the performance of all aspects of endovascular therapy for stroke patients with LVO will be critical to identify and correct institutional obstacles to timely and safe treatment for these patients.

In a general review on cerebral infarction management, the authors state the performance of neurovascular services may be assessed on the basis of times to treatment (*time-to-door, door-to-needle time*) and of quality of care (e.g. stroke centre admission rate, IVT rate, disability and mortality at three months) (82).

► ***American Heart Association / American Stroke Association* (AHA/ASA) guidelines (2018)**

According to the AHA and ASA, healthcare institutions should organise a multidisciplinary quality improvement committee to review and monitor stroke care quality benchmarks, indicators, evidence-based practices, and outcomes. The formation of a clinical process improvement team and the establishment of a stroke care data bank are helpful for such quality of care assurances. The data repository can be used to identify the gaps or disparities in quality stroke care. Once the gaps have been identified, specific interventions can be initiated to address these gaps or disparities (**class I, level of evidence B-NR**).

Continuous quality improvement processes, implemented by each major element of a stroke system of care and the system as a whole, can be useful in improving patient care or outcomes (**class IIa, level of evidence B-NR**).

Stroke outcome measures should include adjustments for baseline severity (**class I, level of evidence B-NR**).

### ► Results of indicators in respect of improvement in the quality and safety of care – 2017 Initial Stroke Management Campaign – 2016 Data

In France, since 2011, indicators in respect of the quality and safety of care relating to "Initial stroke management" have been collected in all MCO healthcare institutions treating at least ten stroke cases per year, due to cerebral infarction or haemorrhage (TIA cases are excluded), at a biennial frequency. Over the years, the set of indicators has been adapted to measure the quality of the intrahospital care pathway.

#### Indicators

In 2017, the following items were particularly collected:

- the "Admission - First-line imaging" time establishing eligibility for thrombolysis in a timely fashion;
- professional rehabilitation assessment facilitating the implementation of rehabilitation adapted to the patient's needs;
- neurovascular assessment establishing the optimum pathway for the patient;
- key data on admission, measuring the NIHSS score and capillary blood glucose the first hour following admission to the institution and recording of the time of symptom onset;
- the functional independence or disability score at discharge providing a reference at MCO service discharge and at the consultation to follow up the patient's outcome.

#### Findings

The "Key data at admission" indicator collected for the first time in 2017 includes three criteria previously collected. Traceability of the date and time of symptom onset has continued to increase; on the other hand, NIHSS and capillary blood glucose traceabilities have decreased since the 2015 campaign, NIHSS score traceability remains low at 45%.

The median "Admission - First-line imaging" time has improved since 2011. Thrombolysis may be performed in the first hours following symptom onset, where patients present with no contraindications to the therapy. Patients admitted in the early stage following stroke (within four hours following symptom onset) should also undergo emergency imaging. The admission-to-imaging time is measured for these patients. In these cases, imaging management is accelerated, 56% of these patients undergo imaging within one hour following their admission, as in 2015. These patients also frequently undergo first-line MRI (47%), whereas this test is conducted as a first-line approach for merely 33% of stroke cases. The development of thrombectomy will undoubtedly require the set-up of an organisation enabling emergency imaging for a greater number of patients.

The weighted proportion of patients admitted to healthcare institutions within times compatible with carrying out thrombolysis remains low at 32%. The weighted proportion of thrombolysis cases according to institution activity in 2017 is 14.2% of patients with a cerebral infarction. It was 11.8% in 2015. The median time between admission to the institution and thrombolysis is 1 hour 09. It is 2 hours 55 between symptom onset and thrombolysis. The proportion of thrombolysis cases has increased considerably since the initiation of research leading to the implementation of the stroke plan. As a reminder, in 2008, it was estimated at 1% of patients.

MT therapy for cerebral infarction in 2017 is recommended within six hours. Of the 39 institutions equipped with the technical resources to carry out MT procedures, 38 performed such procedures. The weighted proportion of patients undergoing MT is 4%.

The "Neurovascular assessment" indicator has increased by 6 points since 2015. This result is due, on one hand, to an increase in the number of patients treated in stroke centres, and, on the other, to the ramp-up of the telestroke scheme throughout the territory. However, the proportion (weighted) of patients not obtaining a neurovascular assessment, or a neurological opinion, is still 11.2% (48).

### ► TJC "*The Joint Commission*" recent basic performance measures for comprehensive stroke centres (2015)

CSTKs[25] include specific performance measure variables. Of the eight basic performance measures for comprehensive stroke centres, three measures overlap for all stroke patients (CSTK-01, documentation of NIHSS score, CSTK-02, documentation of modified Rankin score (mRS) result at 90 days, and CSTK-05, documentation of overall haemorrhagic transformation rate for a stroke patient). Two measures are specific to comprehensive stroke centre performances for LVO IS endovascular therapy: these are CSTK-07, median time to revascularisation, and CSTK-08, TICI post-treatment reperfusion grade.

CSTK-07 requires documentation of the time between hospital admission and the initiation of MT therapy (e.g. the first pass of a medical reperfusion device). However, more specific details of procedures would be even more useful to identify the stages associated with significant treatment delays and minimise the admission-to-revascularisation time. The documentation required for procedural measures is recommended:

- first medical contact at hospital arrival;
- hospital admission to neurovascular team assessment time;
- hospital admission to imaging time (if applicable):
  - recommended less than 10 min;
- imaging (examination and interpretation) to groin puncture time:
  - recommended less than 60 min;
- hospital admission to groin puncture time:
  - recommended less than 90 min;
- groin puncture to first MT attempt time:
  - recommended less than 30 min;
- groin puncture to TICI 2B (satisfactory revascularisation) or higher or conclusion of procedure;
  - recommended less than 60 min (49).

### ► Recommendations of the Society of Vascular and Interventional Neurology (SVIN), 2016

According to the 2016 recommendations of the Society of Vascular and Interventional Neurology (SVIN), other critical procedural data not captured in the current TJC "*The Joint Commission*" comprehensive stroke centre criteria include the following:

- preoperative ASPECTs score and core infarct volume (on baseline CT or MR);
- location of LVO on preoperative vascular imaging and initial diagnostic cerebral angiogram;
- preintervention TICI score;
- use of procedural general anaesthesia versus conscious sedation;
- postintervention infarct volume;
- endovascular complications:

[25] *The comprehensive stroke (CSTK) measures are designed to evaluate the management of both ischemic and hemorrhagic stroke patients in hospitals equipped with the clinical expertise, infrastructure, and specialized neurointerventional and imaging services needed to provide the next level of stroke care*.

- intracranial vessel perforation,
- embolisation to previously uninvolved territory,
- arterial dissection,
- groin haematoma requiring transfusion or surgical repair.

Most importantly, key clinical outcome measures must be obtained and documented, including the following:

- NIHSS at 24 h and hospital discharge;
- symptomatic intracranial haemorrhage;
- discharge destination;
- mRS and NIHSS at discharge and 90 days;
- hospital and 90-day mortality.

Ongoing peer review of these performance measures should be conducted both internally

in any hospital performing MT interventions and against other institutions via a national

database, all in an effort to drive continued workflow quality improvement, with the goals of minimising door to revascularisation times and of ensuring safe and effective use of MT therapies. Specific goals for procedural success and procedural safety, along with metrics for

clinical outcomes, should be determined, and a peer review process (including both internally and those by accrediting bodies) should be triggered when institutions fail to achieve these goals on an annual basis. Fundamental criteria would include the following:

- door to groin puncture times of less than 90 minutes in > 75% of patients;
- TICI 2B or 3 reperfusion > 50%;
- symptomatic intracranial haemorrhage rate < 10%;
- 90-day mortality rate < 25%;
- 90-day mRS of 0–2 > 30% (38).

### ► *European recommendations on organisation of interventional care in acute stroke* (EROICAS) (2016)

- To ensure favourable thrombectomy unit outcomes, the units should routinely collect the key performance indicators listed below:
  - *time from symptom onset to reperfusion*;
  - "*door to imaging*" *time*;
  - "*imaging to groin puncture" time;*
  - "*groin puncture to clot/ first device deployment*" *time*;
  - *degree of reperfusion* (*using the mTICI scale*);
  - *clinical outcomes: mRS at 90 days*;
  - *procedure-related complication rate: symptomatic intracranial haemorrhages* (SICH).
- Key performance indicators should be reported as part of ongoing audits and/or regional, national or international registries.
- Services should monitor performance to minimise door-to-reperfusion times and should report performance metrics in the public domain.
- Target for TICI IIb/III rate should be > 60% (**quality of evidence: moderate, strength of recommendation: strong**).
- Target for imaging (in hospital where EVT is conducted) to femoral puncture time should be, if possible < 30 min and always < 90 min (**quality of evidence: low, strength of recommendation: low**) (37).

### ► Telestroke-specific key performance indicators

The quality of stroke management practices is based on the practices and interconnection of the many disciplines and healthcare professions involved throughout the patient pathway (46).

| From detection to management in institution with or without thrombolysis | |
|---|---|
| **For all suspected stroke cases** | |
| 3. First designated medical contact/admission to imaging time | 3.FPA |
| 4. Rate of EMS/ED physician contact with SC physician | 4.FPA |
| 5. Recording of NIHSS score | 5.FPA |
| 6. MRI completion rate | 6.FPA |
| 7. Rate of imaging with immediate interpretation and written radiologist report | 7.SR |
| **For all cases of confirmed stroke** | |
| 8. Rate of confirmed stroke/TIA patients referred to stroke centre | 8.FPA |
| **For all cases of suspected stroke eligible for thrombolysis at first medical contact and with confirmed cerebral infarction** | |
| 9. First designated medical contact to neurovascular assessment time | 9.FPA |
| 10. Thrombolysis rate and time | 10.FPA |
| **Department treating suspected stroke and/or confirmed stroke cases** | |
| 11. Participation in services with common protocols validated within the services | 11.FPA |

*FPA: Acute Medical Services = EMS, radiology, ED, stroke centre, neurology, geriatrics, medicine; SR: radiology department.*

The indicators are numbered as per the KPIs of the pathway from detection to one-year post-stroke follow-up.

### 8.2.4 Participation in stroke research

**► The current TJC "*The Joint Commission*" eligibility criteria for comprehensive stroke centres state:**

"The CSC will participate in Institutional Review Board-approved patient-centered stroke research". The level 1A data generated by the MR CLEAN, ESCAPE, EXTEND IA, SWIFT PRIME and REVASCAT trials will stimulate numerous future clinical trials focused on optimising endovascular therapy for LVO AIS patients (e.g., the use of advanced imaging for patient selection especially beyond the conventional time window, the evaluation of novel MT devices, the use of procedural sedation, the impact of preoperative neuroprotective strategies). Experienced high-volume comprehensive stroke centres will remain the optimal setting for such stroke research and provide another important reason for directing stroke patients to stroke centres. As part of the performance improvement process within stroke centres, it is essential for a comprehensive stroke centre to have a coordinator tasked with maintenance of an endovascular stroke registry or database that would serve not only as a means of quality improvement but also as a source of meaningful clinical data analysis (49).

**Findings in respect of strategic guidelines**

**Supplement INR activity with MT units**

The projected increase in MT activity requires INR activity supplementation. The aims of this organisation are as follows:

- register patients in care services;
- strengthen the regional network of MT facilities by reinforcing existing interventional neuroradiology facilities and creating new units with MT procedure capability;
- harmonise healthcare institution out-of-hours services;

- increase neuroradiodiagnostic unit availability;
- develop telemedicine;
- the organisation of upstream care services should be reinforced from the first levels (EMS, ED). The organisation of activity on each MT facility should ensure coordinated multidisciplinary patient care.

It is also necessary to anticipate adaptation of care provision services to treat a greater number of patients based on current knowledge of MT procedure growth.

For this, it is first of all needed to reinforce the human and material resources at the 39 comprehensive stroke centres to enable them to carry out the MT activity under optimum conditions and ensuring out-of-hours services. In particular, it will be particularly necessary to ensure that: the stroke centre has a sufficient number of neurologists; a diagnostic imaging unit as defined above; that the INR unit has at least four qualified MT operators (essentially interventional neuroradiologists) and the technical platform defined above.

Moreover, it will be necessary to strengthen the regional network by creating new units, including primary stroke centres supporting MT units. These MT units should have at least three qualified MT operators and the technical platform needed to perform MT defined above (regional health boards may organise pooled out-of-hours services). Unlike an INR unit, these MT units will not carry out all interventional neuroradiology procedures, but will focus on MT procedures. Furthermore, an MT unit shall be able to avail of 24/7 neurosurgical care, in agreement with another institution approved for this activity, or available on-site. This comprehensive stroke centre-INR/primary stroke centre-MT unit shall make it possible to provide graduated care, similar to that in place for thrombolysis access. This graduated care would incorporate a close link between the comprehensive stroke centre-INR and peripheral primary stroke centres-MT units. This strengthened regional network should ideally enable access to these facilities in less than one hour for all patients.

In addition, as mentioned above, it is essential to provide out-of-hours services via the organisation of an interfacility cooperation network for pooling medical resources with the use of telemedicine for the care of patients presenting with a neurovascular condition.

It is also critical to continue to develop telemedicine in interventional neuroradiology, particularly through pre-transfer reviews, and monitoring support. Indeed, this organisation helps minimise losses of opportunity or avoid some transfers to comprehensive stroke centres.

The request for a comprehensive stroke centre neuroradiologist opinion via telemedicine is a means to improve:

- accessibility to specialised diagnosis;
- quality of care;
- streamlining of transfers;
- safeguarding of any remote specialist follow-up;
- stroke centre capacity management.

**MT activity assessment and follow-up**

All of the guidelines recommend setting up an exhaustive registry of patients treated using MT to track the spread of the procedure and obtain data in respect of use in routine practice; moreover, participation in the registry is a means to retain facility certification.

The use of MT therapy shall be subject to tracking based on the following indicators:

- activity indicators;

- care organisation indicators;
- partnership and cooperation indicators;
- quality of care indicators.

# 9. Assessment findings

Stroke is a major healthcare issue due to its frequency and the ensuing risk of disability. As such, each year, approximately 130,000 people suffer from a stroke in France: 40,000 die as a result and 30,000 retain severe after-effects. Furthermore, the number of strokes is increasing by 5% each year in France. Therefore, stroke management is a public health priority.

While early management of ischaemic stroke has been revolutionised by admission to stroke centres and by the option of timely recanalisation of the occluded artery by intravenous thrombolysis (therapeutic window of 4 hours 30), a third revolution is under way, that of mechanical thrombectomy (MT). Indeed, the beneficial impact of this innovation on morbidity, functional status (independence and dependency), and on quality of life at 90 days has been demonstrated by studies with a high level of evidence, leading to National Health Insurance cover in 2017.

## 9.1 PRACTICE REQUIREMENTS

Practice requirements were addressed in part in the first part in respect of MT efficacy and safety. The guidelines analysed within the scope of this assessment relating to the organisational aspect can be used to describe the technical platform for the practice of MT, the diagnostic neurological imaging capabilities required, and the organisation of a unit practising MT. They have been drawn from the best evidence currently available and on the opinion of the experts consulted. As a general rule, these guidelines are in agreement and recommend the following points.

### 9.1.1 Therapeutic decision

- Note: MT is indicated either, from the outset, in combination with intravenous (IV) thrombolysis, as a second-line procedure (after IV thrombolysis treatment failure or on its own in the event of contraindication to IV thrombolysis), within six hours after the onset of symptoms for acute IS patients, associated with anterior circulation LVO visible via imaging.
- In view of the findings of the recent randomised controlled trials (RCTs), DAWN (13) and DEFUSE-3 (14), two indication extensions may be proposed:
  - as such, MT may be recommended in selected patients with AIS within 6 to 16 hours of last known normal, presenting with LVO in the anterior circulation and meeting the eligibility criteria of the DAWN or DEFUSE-3 trials;
  - MT may also be recommended in selected stroke patients within 6 to 24 hours of last known normal, presenting with LVO in the anterior circulation and meeting the eligibility criteria of the DAWN trial.
- Vascular occlusion should be diagnosed non-invasively as a first-line approach (CTA or magnetic resonance angiography) before envisaging the MT therapy phase.
- The decision to carry out MT should be made by a multidisciplinary team including at least one neurologist and/or a medical practitioner with neurovascular disease expertise from an on-site stroke centre and a medical practitioner qualified to perform MT.
- The choice of anaesthetic procedure is decided jointly by the anaesthetist and the interventional neuroradiologist or the medical practitioner qualified to perform MT. This choice is made on the basis of a personalised assessment of the patient's clinical characteristics and risk factors, as well as the technical performances of the procedure. The endpoint is to carry out MT under optimal conditions for the patient without reducing the time to MT treatment.

### 9.1.2 Diagnostic neuroradiology unit

In order to be able to indicate MT, institutions must have the following diagnostic imaging capabilities and equipment:

- 24/7 access to CT scans (perfusion and angiography), MRI (brain MRI and magnetic resonance angiography);

- organisations should enable brain imaging examinations to be carried out in a timely manner following arrival at the emergency department for at least 50% of patients who are potential candidates for intravenous thrombolysis and/or MT;
- imaging capability of the extracranial and vertebral carotid arteries, in addition to the intracranial circulation, in order to assess the patient's eligibility for the endovascular procedure.

### 9.1.3 MT unit

The technical platform for the practice of MT includes at least:

- one interventional angiography suite consisting of a floating table with a dedicated cradle enabling rotational 3D acquisitions;
- this interventional angiography suite should enable the administration of a general anaesthetic under aseptic conditions identical to those of an operating theatre;
- radioprotection measures should be implemented, in accordance with the regulations currently in force.

### 9.1.4 Link between practice of MT and stroke centre

The MT procedure should be an integral part of neurovascular services based on diagnostic imaging and neurological opinion. This implies that, on one hand, all patients who are candidates for MT should be previously admitted to a stroke centre, and, on the other, that the MT procedure may be only be envisaged in a healthcare institution with an accredited stroke centre, in accordance with the criteria set out in the regulations in force (*cf.* section 1.2.2).

These healthcare institutions should have the following:

- a stroke centre-affiliated vascular neurology team available 24/7, physically present on-site or accessible via telemedicine;
- 24/7 MT interventionalists;
- a team of radiologists available 24/7, present on-site or via telemedicine and advanced imaging equipment (*cf.* "diagnostic imaging capability" section);
- neurosurgical care available 24/7 on-site or in agreement with another institution approved for this activity;
- an NICU unit available 24/7;
- at least three MT interventionalists trained for MT management within the framework of an MT or INR unit, regional health boards organising pooled out-of-hours services if required;
- standardised protocols for the management of patients from their arrival at the institution;
- expert postoperative management of IS patients associated with LVO;
- moreover, these healthcare institutions should also:
  - have radioprotection measures for patients and operators,
  - have an interfacility transfer protocol (with other stroke centres/units) in accordance with the regional organisation defined by the regional health board,
  - participate in the healthcare professional registry of practices in accordance with HAS recommendations,
  - complete HAS indicators for the improvement of the quality and safety of care in respect of initial stroke management.

## 9.2 TEAM COMPOSITION AND PROFESSIONAL TRAINING

### 9.2.1 MT team composition

Based on all of the guidelines analysed and the opinions of the stakeholders, the composition of the medical and paramedical team required to carry out MT under optimal conditions is as follows:

- an MT interventionalist (*cf.* skills below);
- an anaesthetist with experience in caring for patients treated with interventional neuroradiology procedures;

- a medical radiographer;
- a state-qualified anaesthesia nurse (IADE);
- a surgical assistant (medical practitioner, nurse or medical radiographer).

### 9.2.2 MT interventionalist skills

MT interventionalists are required to have appropriate training and experience for the performance of neuroangiography and mechanical thrombectomy. The cognitive requirements consist of baseline training and qualifications, as well as ongoing professional education, which are essential for safe and efficient patient management.

The common foundation pertaining to clinical endpoints, training, MT regimens is based on a high level of skills:

- imaging and radioprotection expertise;
- percutaneous guidance and endovascular navigation expertise;
- expertise in clinical assessment and diagnostic and therapeutic patient management.

The technical skills for the MT procedure require:

- capacity to perform, conduct, and interpret standard diagnostic neuroradiology (CT scan, MRI, multimodal-imaging) for appropriate case selection;
- capacity to perform, conduct, and interpret MT procedures, as well as management skills for procedural complications;
- skills in the interdisciplinary management of ischaemic stroke patients with neurologists/neurosurgeons or other medical practitioners involved in stroke management in stroke centres;
- ongoing upgrading of diagnostic and therapeutic methods and skills required to carry out MT.

### 9.2.3 Initial training

Based on the international guidelines reviewed, training of interventional neuroradiologists and MT interventionalists should include theoretical and practical training in clinical neuroscience, diagnostic neuroradiology, and interventional neuroradiology.

In France, following the 2017 reform of post-graduate medical studies, the "Advanced interventional radiology" option offered in the post-graduate diploma in "radiology and medical imaging" currently solely accessible to radiology interns, aims to provide, over two years, training and expertise in "advanced, complex interventional radiology (IR) procedures", including MT. The theoretical and practical teaching for this option is carried out in *"radiology departments with teams qualified to carry out complex IR procedures in respect of subspecialties"*, namely, stroke centre INR units, and makes it possible to acquire the skills mentioned above.

At the present time, no MT-specific specialised cross-disciplinary training (SCDT) is available enabling other medical specialties (neurologists, neurosurgeons, etc.) to be trained on carrying out MT within the framework of initial training.

In order to meet future care needs, HAS proposes extending MT training to other radiologists and to other medical specialties (neurologists, neurosurgeons and subsequently, if the need is not sufficiently covered, to interventional cardiologists), from the initial training stage by setting up specific SCDT.

### 9.2.4 Continuous training

The analysis of the literature demonstrated that, unlike initial training, there are a number of examples of continuous medical training enabling non-interventional neuroradiologists (neurologists, neurosurgeons, interventional radiologists, diagnostic neuroradiologists) to acquire the theoretical and practical skills required (clinical neuroscience, diagnostic neuroradiology and interventional neuroradiology) to perform INR, including MT. Note that the UK also provides such training open to cardiologists. The training durations vary from two to four years.

In France, an interuniversity diploma (DIU) in diagnostic and therapeutic neuroradiology is now available, making it possible to validate the two years of essential theoretical training to be able to practise comprehensive INR as a senior medical practitioner. This diploma is open to radiologists, neurosurgeons, and neurologists. On the other hand, no MT-specific continuous medical training is available.

Therefore, HAS proposes to create MT-specific continuous training, open to other radiologists and to other medical specialties (neurologists, neurosurgeons and subsequently, if the need is insufficiently covered, to interventional cardiologists).

### 9.2.5 Minimum activity threshold for MT interventionalists

Skills development is based on continuous professional development (CPD) and on a minimum activity threshold per interventionalist. Indeed, the *British Society of Neuroradiologists* has proposed that the minimum MT activity be 30 cases per year. This should be compared to the threshold of 30 intracranial neurovascular cases per year proposed by the *Royal College of Radiologists*, and the value of 40-50 MT cases per year proposed by SFNR (value corresponding to the average French MT activity/operator in 2017). However, no consensus has been reached on the value of this activity threshold.

### 9.2.6 Minimum activity threshold for MT units

Failing literature of a sufficient level of evidence, HAS, based on expert opinion, proposes an initial annual threshold of 60 cases. This threshold level should be assessed during the ramp-up phase and after five years in the light of the number and distribution of cases.

Moreover, this minimum activity threshold may also be modulated by the Ministry of Health or regional health boards based on specific scenarios (opening of a new unit, ramp-up of activity of a newly trained interventionalist, ultramarine context). Smoothing of the activity over a number of years (e.g. three years) may also be envisaged.

## 9.3 CARE PATHWAY OF THE MT CANDIDATE

### 9.3.1 MT candidate patient pathway

The patient pathway includes a number of stages:

- prehospital phase: patient call and dispatch to stroke centre or healthcare institution linked to stroke centre via telemedicine;
- patient selection based on neurological examination and cerebrovascular imaging: in the case of telemedicine, the clinical examination is conducted by the neurologist and the radiological interpretation is carried out by a radiologist with vascular neuroradiology expertise;
- establishment of MT indication: neurological and neuroradiological consultation on-site or via remote assessment;
- contact of anaesthetist;
- dispatch to stroke centre equipped with an MT unit or INR unit - MT procedure;
- return to specialised ward in stroke centre or to neurointensive care unit or comprehensive stroke centre.

### 9.3.2 Detection: information and awareness

Note: the description of alert procedures (15 emergency advice line, call handling, emergency medical services, etc.), provided in this report, is based on the current organisation and regulations. This description will be subject to change in the event of modifications of the organisation and regulations of detection procedures.

Activation of the alert by calling the 15 emergency advice line, call handling and urgent dispatch to an identified hospital are critical for expeditious patient care and enable MT procedures under optimal conditions.

Information in general public campaigns on early management of stroke cover the following three main areas:

- identifying symptoms indicating a potential stroke;
- the existence of emergency care and treatments (admission to stroke centre and thrombolysis);
- the need for emergency aid as a matter of priority by contacting the centre 15 advice line.

The key messages to be broadcast to professionals providing stroke management services include the need to:

- consider any sudden, transient or sustained neurological deficit as an absolute emergency;
- record the precise time of the onset of symptoms;
- be aware of the effectiveness of the care provided in stroke centres;
- be aware of specific therapies for stroke.

### 9.3.3 In the prehospital phase

- **Patient assessment**

Early management is critical in cases of stroke, during the prehospital phase, professionals should be provided with simple tools suitable for timely use.

The FAST score meaning *(face, arm, speech, time*) is simple and universally accessible and is used to assess the likelihood of stroke in suspected patients. Awareness should be raised among primary care teams, other healthcare personnel and the entourage of at-risk patients on the early symptoms of stroke, and training provided on the use of the FAST test. Moreover, all emergency physicians should be capable of using the NIHSS scale (*National Institutes of Health Stroke Scale*) and assessing stroke severity.

- **Call handling**

The role of EMS call handling and prehospital patient transportation, which is already critical in stroke services, should be reinforced further in thrombectomy management.

The primary aim is to get the patient to the right place at the right time: operational stroke services should be activated by calling the 15 advice line, guaranteeing a rapid response and expertise; the EMS call handling centre understands the urgency of the call, and transfers it without delay to the triage physician, who deciphers the symptoms suggestive of stroke provided by the entourage and requests a transfer via the most expeditious means available.

- **Patient transfer**

Intra- and interfacility transfer protocols and procedures guaranteeing safe and effective care for patients should be defined and adopted in advance. These protocols should enable efficient transfers at all times, even during out-of-hours services. In cases of medicalised transport, it is recommended to take blood samples enabling laboratory profiling.

All suspected stroke patients should be transferred to the nearest stroke centre regardless of administrative boundaries. Failing a stroke centre nearby, the patient is transferred to an institution with an emergency department and, if possible, a neurology department or unit. The emergency department must have implemented a protocol for stroke management in the context of neurovascular care services thereby enabling that the patient receives care as quickly as possible. Telemedicine linked with the reference stroke centre makes it possible to delegate the intravenous fibrinolysis procedure to the emergency physician, before transferring the patient to the nearest INR unit.

The two potential models for MT may be described as follows:

- "***drip and ship***" (two-phase transfer): initial transfer to the nearest primary stroke centre for diagnosis and intravenous thrombolysis, followed by expeditious transfer to an INR unit for MT;
- "***mothership***": direct transfer to comprehensive stroke centre capable of carrying out thrombolysis, MT, and other required neuroscience support services.

**The optimal model is dependent on the regional network, population density, transport infrastructure and distance from the INR unit**. "*Drip and ship"* might be the more appropriate solution for more remote areas, while a "*mothership*" model might be a good solution for urban city populations which are generally close to a comprehensive stroke centre. However, while preliminary data of a low level of evidence suggest a lack of significant difference between the two models, randomised controlled prospective clinical trials (ongoing or in the pipeline) are needed to establish a definitive opinion.

### 9.3.4 Telestroke in the care pathway

The telestroke scheme (*cf.* section 1.1.4) enables neurovascular and radiological expertise to be shared with institutions where it is not available. For many localities, it enables access to this expertise within short time-frames.

Telestroke networks are useful for triaging stroke patients who may be eligible for interfacility transfer in order to be considered for MT.

In view of the limited distribution and availability of neurological, neurosurgical, and radiological expertise, the use of telemedicine/telestroke resources and systems may bridge this gap and should be supported by the healthcare system.

Adequate 24/7 coverage should be available for the care of acute stroke patients.

### 9.3.5 In the hospital phase

The progressive development of stroke centres throughout the territory in particular, and the structuring of care services should enable initial hospital management, organised around stroke centres. Intrahospital neurovascular services should be organised in advance, coordinated with all the stakeholders involved (emergency physicians, neurologists, radiologists, resuscitation specialists, pathologists, etc.) and defined with written procedures. They should prioritise expeditious access to neurovascular expertise and to brain imaging by optimising the organisation of structural and functional aspects.

- **Hospital admission**

Therefore, timely patient dispatch to hospital after the onset of neurological symptoms needs to be coordinated with timely and organised intrahospital care. The specific organisation of prehospital emergency case management (call handling or medicalised transport) is only effective if it can rely on a coordinated hospital handover. Interaction between these two phases optimises treatment times. Moreover, the prehospital call handling service should be aware of the different locations capable of accommodating suspected stroke patients for the different institutions. Depending on the organisation of each institution, these may be the emergency, imaging department, or stroke centre.

Patients eligible for MT are selected subject to a multidisciplinary review including a neurologist, a neuroradiologist and an anaesthetist based on the clinical examinations and imaging findings, obtained on-site or forwarded via telemedicine. The first procedure is to carry out brain imaging with a view to confirming cerebral infarction.

- **Patient information and consent**

The effect of MT on disability makes it a worthwhile therapy that improves patient-centred outcomes. It is recommended that physicians should proceed without delay to MT in cases where the patient is without capacity for informed consent and no legally authorised representative is available. Hospitals and other healthcare organisations should establish protocols that explicitly recom-

mend that the physician act under the doctrine of implied consent, based on what a reasonable patient would choose in this scenario.

## 9.4 OVERVIEW OF CARE PROVISION IN FRANCE

### 9.4.1 Interregional Schemes of Healthcare Organisation

The aim of the Interregional Schemes of Healthcare Organisation (SIOS) is to optimise the response to healthcare needs by ensuring synergy of expertise while retaining a good degree of accessibility to care provision for the areas concerned, including interventional neuroradiology. These aspects are therefore defined in principle by the regional health boards (ARS). Cerebral vascular accidents (CVA, or stroke) are one of the main conditions treated using INR.

All of the SIOS documents analysed agree and highlight the prospect of MT development which represents a challenge for interventional neuroradiology teams. This activity requires the shortest possible time to treatment after the onset of stroke (six hours), and therefore 24/7 availability of a medical and paramedical team. According to the SIOS schemes, the potentially foreseeable increase in MT procedures is driving growth in interventional neuroradiology teams and general anaesthesia teams (for a portion of these procedures).

Each region must organise the neurovascular services for its own locality. Harmonious development of interregional telemedicine (telestroke) in terms of interventional neuroradiology activities will particularly make it possible to envisage sharing expertise (telemedicine) between INR units, based on models to be defined with the stakeholders concerned.

### 9.4.2 Regional organisation of neurovascular services

The SFNR survey findings report an estimated increase in activity of over 20% between 2016 and 2017, with an update in 2018 demonstrating an MT activity of up to 5591 cases in 2017, i.e. 15 MT procedures per day. Moreover, regional disparities, with nonetheless an overall increase, but varying according to the centres, are observed.

The MT activity is broken down into daytime and night-time activity, 25% in the middle of the night, and 35% at weekends. It is covered by 109 senior practitioners and 28 practitioners are currently in training.

The average distance of INR units from primary stroke centres is 83±53 km. The estimated transfer times are less than 60 minutes (67.2% of centres) and more than 60 min (34.8%).

The survey conducted on the regional health boards made it possible to describe the regional specificities causing problems accessing the procedure and identify the challenges in respect of the optimal roll-out of MT.

### 9.4.3 Issue of accessibility of care provision and structure of services

Regional specificities, such as the area, geographic position, remote or mountainous areas, raise the question of the adequacy of the INR provision network to ensure times to treatment that are compatible with patient safety. The structure of neurovascular services (call handling, emergency department, radiology, stroke centre) enables optimal management of patients eligible for IV thrombolysis, but requires adaptation for MT:

- adapt admission capacities to the population's needs (stroke centre, ICU, post-stroke consultations, telemedicine, discharge and return home, rehabilitation);
- conduct proper regional coordination of stroke services, in a comprehensive manner, incorporating all expertise and management needs: thrombolysis and MT;
- account for the coordinated key expertise necessary for management: out-of-hours services, EMS call handling, role of emergency physicians, neurologists, neuroradiologists, teams of anaesthetists, radiologists and suitable staff (caregivers, porters, healthcare executives, etc.) for cases requiring care in tight time-frames;

- offer suitable care provision, in particular 24-hour imaging (MRI) in facilities with an ICU/stroke centre: the option to refer for MRI or CT perfusion on a 24/7 basis in MT centres, with adequate staff (physicians, radiographers) and organisation, would make it possible to offer the population superior diagnostic coverage;
- continue to harmonise care: common protocols, common systems. etc.;
- develop interfacility cooperation for graduated care which helps reduce inequalities of access to care.

### 9.4.4 Issue of out-of-hours services

Accessibility applies to the management of emergency cases, particularly in the context of out-of-hours services. It challenges both medical and paramedical resources and accessibility to interventional neuroradiology suites in a surgical setting. Due to the increase in MT procedures, medical staffing levels need to evolve to support needs associated with the activity and the obligation to provide out-of-hours services. Human resources are deemed to be lacking by all of the regions to be able to provide satisfactory out-of-hours services.

At the present time, out-of-hours services, both in diagnostic terms via telemedicine and in terms of clinical procedures, must be organised in concert with the EMS who must be aware of the care provision availability on a regional scale.

A pooling of diagnostic and interventional on-call lines is observed in some regions.

### 9.4.5 Issue of compliance with standards, quality and safety of care

In the human resources section, the presence of four experienced staff members when performing an interventional neuroradiology procedure, including MT, appears to be difficult to achieve in all regional INR facilities.

Furthermore, it is necessary to add the issue of the shortage of hospital medical anaesthetists, worsened by growth in this activity.

Due to the increased prevalence in the future of MT indications in the treatment of ischaemic stroke cases, it will be necessary to have a second suite (biplanar or monoplanar) available in the years to come.

Interventional neuroradiology activity should be carried out in an operating suite setting. In addition, interventional vascular neurology procedures should only be performed in the vicinity of a neurosurgical team and a stroke centre.

A further point of which to be mindful, raised by regional health boards, relates to interventional neuroradiology team staffing and training to be able to cope with the growth in the activity without prejudicing the quality/safety of care.

### 9.4.6 Issue of cooperation and development of information systems

Cooperation arrangements between institutions in a number of regions are in place. Some regional health boards note the need to continue definition and promote the development of suitable information systems.

### 9.4.7 Issue of better valuation of INR activity, including MT

The valuation of MT admissions and night-time working hours could increase the appeal of INR.

## 9.5 STRATEGIC GUIDELINES

### 9.5.1 Supplement INR activity with MT units

The projected increase in MT activity requires INR activity supplementation. The aims of this organisation are as follows:

- register patients in care services;
- strengthen the regional network of MT facilities by reinforcing existing interventional neuroradiology facilities and creating new units with MT procedure capability;
- harmonise healthcare institution out-of-hours services;
- increase neuroradiodiagnostic unit availability;
- develop telemedicine.

The organisation of upstream care services should be reinforced from the first levels (EMS, ED). The organisation of activity on each MT facility should ensure coordinated multidisciplinary patient care.

It is also necessary to anticipate adaptation of care provision services to treat a greater number of patients based on current knowledge of MT procedure growth.

For this, it is first of all needed to reinforce the human and material resources at the 39 comprehensive stroke centres to enable them to carry out the MT activity under optimum conditions and ensuring out-of-hours services. In particular, it will be necessary particularly to ensure that: (i) the stroke centre has a sufficient number of neurologists, a diagnostic imaging unit as defined above; that the INR unit has at least four qualified MT operators and the technical platform defined above.

It would be necessary to strengthen the regional network by creating new centres, including primary stroke centres supporting MT units.

This new organisation would make it possible to provide graduated care, similar to that in place for thrombolysis access, based on four types of healthcare institutions.

- "Comprehensive stroke centre" healthcare institutions with:
  - a stroke centre with continuous medical services, 24-hour neurovascular expertise (on duty or on-call);
  - 24-hour MRI or CT brain imaging capability enabling on-site IV thrombolysis;
  - interventional neuroradiology and neurosurgery units to care for patients requiring specific expertise and specialised neurosurgery and interventional neuroradiology procedures (including MT).
- "MT unit" healthcare institutions with:
  - a stroke centre with continuous medical services, 24-hour neurovascular expertise (on duty or on-call);
  - 24-hour MRI or CT brain imaging capability enabling on-site IV thrombolysis;
  - a designated MT unit for treating patients presenting with ischaemic stroke and requiring an MT procedure;
  - neurosurgical care available 24/7 on-site or in agreement with another institution approved for this activity.
- "Primary stroke centre" healthcare institutions with:
  - a stroke centre with continuous medical services, 24-hour neurovascular expertise (on duty or on-call);
  - 24-hour MRI or CT brain imaging capability enabling on-site IV thrombolysis.
- Healthcare institutions with no stroke centre, but attending to emergency cases and provided with protocols, procedures and a diagnostic imaging unit enabling early management of stroke patients, specific diagnosis and organisation of patient care, by obtaining a neurologist's opinion from a stroke centre with which it is contracted and organising transfer to a stroke centre if required.

This strengthened regional network should ideally enable access to these facilities in less than one hour for all patients.

Moreover, as mentioned above, it is essential to provide out-of-hours services via the organisation of an interfacility cooperation network for pooling medical resources with the use of telemedicine for the care of patients presenting with a neurovascular condition.

It is also critical to continue to develop telemedicine in interventional neuroradiology, particularly through pre-transfer reviews, and monitoring support. Indeed, this organisation helps minimise losses of opportunity or avoid some transfers to comprehensive stroke centres.

The request for a comprehensive stroke centre neuroradiologist opinion via telemedicine is a means to improve:

- accessibility to specialised diagnosis;
- quality of care;
- streamlining of transfers;
- safeguarding of any remote specialist follow-up;
- stroke centre capacity management.

### 9.5.2 MT activity assessment and follow-up

All of the guidelines recommend setting up an exhaustive registry of patients treated using MT to track the spread of the procedure and obtain data in respect of use in routine practice. Moreover, participation in the registry is a means to retain facility certification.

The use of MT therapy shall be subject to tracking based on the following indicators:

- activity indicators;
- care organisation indicators;
- partnership and cooperation indicators;
- quality of care indicators.

# 10. HAS recommendations

In view of the points described above, HAS has issued the following recommendations:

**R1 → Expand the pool of physicians with MT expertise in order to meet future care needs by extending MT training (initial SCDT and continuous training) to other radiologists and to other medical specialities (neurologists, neurosurgeons and, if the need is not sufficiently covered, to interventional cardiologists).**

**R2 → Increase the human and material resources of the 39 stroke centres in order to provide MT under optimum conditions.**

In particular, it will be necessary to ensure that:

- the stroke centre has a sufficient number of neurologists;
- a diagnostic imaging unit;
- at least four qualified MT interventionalists (the regional health boards may organise pooled out-of-hours services).

**R3 → Create complementary care provision by setting up new MT units within healthcare institutions already including primary stroke centres.**

Unlike an INR unit, these MT units will not carry out all interventional neuroradiology procedures, but will focus on MT procedures.

These MT units should be provided with, in particular:

- at least three qualified interventionalists with MT expertise, to cover the needs arising from practice requirements and out-of-hours services (the regional health boards may organise pooled out-of-hour services);
- the technical platform required to conduct MT defined above;
- neurosurgical care available 24/7 on-site or in agreement with another institution approved for this activity.

The exact determination of the number and location of these MT units affiliated with primary stroke centres will be carried out by the regional health boards based on specific criteria (travel times to comprehensive stroke centre, population pool size, comprehensive stroke centre capacity, continuity of care, etc.).

**R4 → Define a minimum activity threshold in respect of MT procedures annually and per unit. Failing literature of a sufficient level of evidence, HAS, on the opinion of experts, proposes an initial annual threshold of 60 cases. This threshold level should be assessed during the scheme ramp-up phase and after five years, in the light of the number and distribution of cases.**

Moreover, this minimum activity threshold may also be modulated by the Ministry of Health or regional health boards based on specific scenarios (opening of a new unit, ramp-up of activity). Smoothing of the activity over a number of years (e.g. three years) may be envisaged. Specific MT follow-up indicators will also be put in place, in order to enable the follow-up of the suitability of MT procedures in particular.

**R5 → Promote and repeat information campaigns aimed at the general public. The information should not be restricted to subjects with vascular risk factors, but should target the population as a whole, including young people.**

# References

1. Larrue V. Accidents ischémiques cérébraux. Encyclop Méd Chir Angéiologie 2015;19-0560.

2. Haute Autorité de Santé. Thrombectomie des artères intracrâniennes par voie endovasculaire. Saint-Denis La Plaine: HAS; 2016. https://www.has-sante.fr/portail/upload/docs/application/pdf/2016-11/rapport_thrombectomie.pdf

3. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J*, et al.* Randomized assessment of rapid endovascular treatment of ischemic stroke. N Engl J Med 2015;372(11):1019-30.

4. Saver JL, Goyal M, Bonafe A, Diener HC, Levy EI, Pereira VM*, et al.* Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. N Engl J Med 2015;372(24):2285-95.

5. Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A*, et al.* Thrombectomy within 8 hours after symptom onset in ischemic stroke. N Engl J Med 2015;372(24):2296-306.

6. Campbell BC, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N*, et al.* Endovascular therapy for ischemic stroke with perfusion-imaging selection. N Engl J Med 2015;372(11):1009-18.

7. Berkhemer OA, Fransen PS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ*, et al.* A randomized trial of intraarterial treatment for acute ischemic stroke. N Engl J Med 2015;372(1):11-20.

8. Bracard S, Ducrocq X, Mas JL, Soudant M, Oppenheim C, Moulin T*, et al.* Mechanical thrombectomy after intravenous alteplase versus alteplase alone after stroke (THRACE): a randomised controlled trial. Lancet Neurol 2016.

9. Décret n° 2007-366 du 19 mars 2007 relatif aux conditions d'implantation applicables aux activités interventionnelles par voie endovasculaire en neuroradiologie et modifiant le code de la santé publique (dispositions réglementaires) Journal Officiel 2007;21 Mars(68).

10. Décret n° 2007-367 du 19 mars 2007 relatif aux conditions techniques de fonctionnement applicables aux activités interventionnelles par voie endovasculaire en neuroradiologie Journal Officiel 2007;21 Mars(68).

11. Ministre de la santé et des sports. Arrêté du 15 mars 2010 fixant les conditions permettant de justifier d'une formation et d'une expérience dans la pratique d'actes interventionnels par voie endovasculaire en neuroradiologie [En ligne] 2010. https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=LEGITEXT000022046098&dateTexte=20161217

12. Société française de Neuroradiologie. Charte des conditions de réalisation de la thrombectomie mécanique en France. Paris: SFN; 2016. http://www.sfnr.net/neuroradiologie-quotidien/thrombectomie/charte-thrombectomie

13. Société française neuro-vasculaire, Mazighi M, Cognard C. Place de la thombectomie mécanique dans la prise en charge à la phase aiguë de l'infarctus cérébral par occlusion des artères de la circulation antérieure. Paris: SFNV; 2015. http://www.sfmu.org/upload/consensus/preco_thrombectomie_sfnv2015.pdf

14. Agence Nationale d'Accréditation et d'Evaluation en Santé. Place des unités neuro-vasculaires dans la prise en charge des patients atteints d'accident vasculaire cerebral. Paris: ANAES; 2002. https://www.has-sante.fr/portail/upload/docs/application/pdf/2009-12/unv_synth.pdf

15. Haute Autorité de Santé. Accident vasculaire cérébral : prise en charge précoce (alerte, phase préhospitalière, phase hospitalière initiale, indications de la thrombolyse). Saint-Denis La Plaine: HAS; 2009. http://www.has-sante.fr/portail/upload/docs/application/pdf/2009-07/avc_prise_en_charge_precoce_-_recommandations.pdf

16. Ministère de la santé et des sports, Ministère du travail de la solidarité et de la fonction publique, Ministère de l'enseignement supérieur et de la recherche. Plan d'actions national "accidents vasculaires cérébraux 2010-2014". Paris: Ministère de la santé et des sports; 2010.

17. Direction de l'hospitalisation et de l'organisation des soins, Sous-direction de l'organisation du système de soins, Bureau des dispositifs nationaux et centralisés de l'offre de soins. Circulaire DHOS du 22 mars 2007 relatuive à la place des unités neurovasculaires dans la prise en charge des patients présentant un AVC. Bulletin Officiel 2007;07-04.

18. Desal H, Bourcier R, Sevin M, Guillon B. Recommandations et organisation territoriale de la thrombectomie mécanique : exemple de Nantes. Pratique Neurologique - FMC 2016;7:87-91.

19. Haute Autorité de Santé. Résultats des indicateurs pour l'amélioration de la qualité et la sécurité des soins. Prise en charge initiale de l'accident vasculaire cérébral. Campagne 2017 – Données 2016 Saint-Denis La Plaine: HAS; 2017. https://www.has-sante.fr/portail/upload/docs/application/pdf/2017-12/plaquette_avc_2017.pdf

20. Ministère de la santé de la famille et des personnes handicapées, Direction de l'hospitalisation et de l'organisation des soins, Sous-direction de l'organisation du système de soins, Direction générale de la santé. Circulaire DHOS/DGS/DGAS n°517 du 3 novembre 2003 relative à la prise en charge des accidents vasculaires cérébraux. Bulletin Officiel 2003;03-47.

21. Ministère du travail de l'emploi et de la santé, Direction générale de l'offre de soins, Sous-direction de la régulation de l'offre de soins, Bureau des prises en charges post-aiguës pathologies chroniques et santé mentale, Bureau plateaux techniques et prises en charge hospitalières aiguës. Circulaire DGOS/R4/R3/PF3 no

2012-106 du 6 mars 2012 relative à l'organisation des filières régionales de prise en charge des patients victimes d'accident vasculaire cérébral (AVC). Bulletin Officiel 2012;12-04.

22. Le ministre de la santé et des solidarités. Arrêté du 19 mars 2007 fixant l'activité minimale des établissements pratiquant les activitées interventionnelles par voie endovasculaire en neuroradiologie. Journal Officiel 2007;21 mars(68).

23. LOI n° 2009-879 du 21 juillet 2009 portant réforme de l'hôpital et relative aux patients, à la santé et aux territoires - Article 78. Journal Officiel 2009; 22 juillet (167).

24. Décret n° 2010-1229 du 19 octobre 2010 relatif à la télémédecine. Journal Officiel 2010;21 octobre(245).

25. Direction générale de l'offre de soins. Guide méthodologique pour l'élaboration du programme régional de télémédecine. Paris: Minstère du travail de l'emploi et de la santé; 2012. http://solidarites-sante.gouv.fr/IMG/pdf/guide_methhodologique_elaboration_programme_regional_telemedecine.pdf

26. Direction générale de l'offre de soins, Sous-direction des ressources humaines du système de santé, Bureau RH 2 « exercice ddpc. Télémédecine et responsabilités juridiques engagées Paris: Ministère de l'emploi du travail et de la solidarité; 2012. http://esante.gouv.fr/sites/default/files/Telemedecine_et_responsabilites_juridiques_engagees.pdf

27. Nogueira RG, Jadhav AP, Haussen DC, Bonafe A, Budzik RF, Bhuva P*, et al.* Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct. N Engl J Med 2018;378(1):11-21.

28. Albers GW, Marks MP, Kemp S, Christensen S, Tsai JP, Ortega-Gutierrez S*, et al.* Thrombectomy for Stroke at 6 to 16 Hours with Selection by Perfusion Imaging. N Engl J Med 2018;378(8):708-18.

29. Daubail B, Ricolfi F, Thouant P, Vogue C, Chavent A, Osseby GV*, et al.* Impact of mechanical thrombectomy on the organization of the management of acute ischemic stroke. Eur Neurol 2016;75(1-2):41-7.

30. Ryu WHA, Avery MB, Dharampal N, Allen IE, Hetts SW. Utility of perfusion imaging in acute stroke treatment: a systematic review and meta-analysis. J Neurointerv Surg 2017;9(10):1012-6.

31. Smith EE, Schwamm LH. Endovascular clot retrieval therapy: implications for the organization of stroke systems of care in North America. Stroke 2015;46(6):1462-7.

32. Evans MRB, White P, Cowley P, Werring DJ. Revolution in acute ischaemic stroke care: a practical guide to mechanical thrombectomy. Pract Neurol 2017;17(4):252-65.

33. Jansen O, Szikora I, Causin F, Bruckmann H, Lobotesis K. Standards of practice in interventional neuroradiology. Neuroradiology 2017;59(6):541-4.

34. American Heart Association, American Stroke Association, Powers WJ, Derdeyn CP, Biller J, Coffey CS*, et al.* 2015 American Heart Association/American Stroke Association Focused update of the 2013 guidelines for the early management of patients with acute ischemic stroke regarding endovascular treatment: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2015;46(10):3020-35.

35. American Heart Association, American Stroke Association, Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM*, et al.* 2018 Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2018;49(3):e46-e110.

36. Royal College of Physicians, Intercollegiate Stroke Working Party. National clinical guideline for stroke. London: RCP; 2016. https://www.strokeaudit.org/SupportFiles/Documents/Guidelines/2016-National-Clinical-Guideline-for-Stroke-5t-(1).aspx

37. European Academy of Neurology (EAN), European Association of Neurosurgical Societies (EANS), European Society of Emergency Medicine (EuSEM), European Society of Minimally Invasive Neurological Therapy (ESMINT), European Stroke Organisation (ESO), Fiehler J*, et al.* European Recommendations on Organisation of Interventional Care in Acute Stroke (EROICAS). Int J Stroke 2016;11(6):701-16.

38. Society of Vascular and Interventional Neurology (SVIN), English JD, Yavagal DR, Gupta R, Janardhan V, Zaidat OO*, et al.* Mechanical thrombectomy-ready comprehensive stroke center requirements and endovascular stroke systems of care: Recommendations from the Endovascular Stroke Standards Committee of the Society of Vascular and Interventional Neurology (SVIN). Interv Neurol 2016;4(3-4):138-50.

39. American Association of Neurological Surgeons, Congress of Neurological Surgeons, American Society of Neuroradiology, Asian Australasian Federation of Interventional and Therapeutic Neuroradiology, Australian and New Zealand Society of Neuroradiology, Lavine SD*, et al.* Training guidelines for endovascular stroke intervention: an international multi-society consensus document. Neuroradiology 2016;58(6):537-41.

40. American Academy of Neurology, Cerebrovascular Section, Surgery SoN, Society of Vascular and Interventional Neurology, Meyers PM, Schumacher HC*, et al.* Performance and training standards for endovascular ischemic stroke treatment. AJNR Am J Neuroradiol 2010;31(1):E8-11.

41. American Academy of Neurology, American Association of Neurological Surgeons/Cerebrovascular Section, Society of NeuroInterventional Surgery, Society of Vascular & Interventional Neurology, Meyers PM, Schumacher HC*, et al.* Performance and training standards for endovascular acute ischemic stroke treatment. Neurology 2012;79(13 Suppl 1):S234-8.

42. British Society of Neuroradiologists, UK Neurointerventional Group. BSNR training guidance for mechanical thrombectomy. London: Royal College of Radiologists; 2016. http://bsnr.org.uk/wp-content/uploads/2016/06/BSNR-training-response-to-MT-evidence-FINAL-23.1.16.pdf

43. Royal College of Physicians and Surgeons of Canada, Stotts G, Poppe AY, Roy D, Jovin TG, Lum C*, et al.* Defining the role of the stroke physician during

endovascular therapy of acute ischemic stroke. Stroke 2017.

44. Magdon-Ismail Z, Benesch C, Cushman JT, Brissette I, Southerland AM, Brandler ES*, et al.* Establishing recommendations for stroke systems in the thrombectomy era: The upstate New York stakeholder proceedings. Stroke 2017.

45. Haute Autorité de Santé. « Ensemble, améliorons les pratiques de prise en charge de l'Accident Vasculaire Cérébral (AVC) ». Saint-Denis La Plaine: HAS; 2010. https://www.has-sante.fr/portail/upload/docs/application/pdf/2011-10/avc_synthese_indicateurs_site_vf.pdf

46. Haute Autorité de Santé. Télé AVC. Prise en charge en urgence - service des urgences, SAMU/ SMUR, service de radiologie, UNV. Saint-Denis La Plaine: HAS; 2013. https://www.has-sante.fr/portail/upload/docs/application/pdf/2013-06/ipc_avc_tlmedecine_vf.pdf

47. Bruder N, Boussen S. Accident vasculaire cérébral ischémique. Anesthésie et Réanimation 2017;3(1):25-36.

48. Haute Autorité de Santé. Résultats des indicateurs et impact des dispositifs d'amélioration de la qualité (IQSS). Saint-Denis La Plaine: HAS; 2018. https://www.has-sante.fr/portail/jcms/c_970821/fr/resultats-des-indicateurs-et-impact-des-dispositifs-d-amelioration-de-la-qualite-iqss

49. Joint Commission, Vieweg T, Kolbusz K, Eickemeyer D. An overview of the new thombectomy-capable stroke center certification. Oakbrook Terrace: JC; 2017. https://www.jointcommission.org/assets/1/6/TSC_Overview_Webinar_091317.pdf

50. Training guidelines for endovascular ischemic stroke intervention: An international multi-society consensus document. Interv Neuroradiol 2016;22(3):256-9.

51. Société française de Radiologie, Fédération de Radiologie interventionnelle. La radiologie interventionnelle en France SFR: Paris; 2011. http://www.sfrnet.org/rc/org/sfrnet/htm/Article/2011/htm-20110201-160438-609/src/htm_fullText/fr/Pr%C3%A9sentation%20RI%20en%20france%20en%202010%20V2.pdf

52. Arrêté du 21 avril 2017 relatif aux connaissances, aux compétences et aux maquettes de formation des diplômes d'études spécialisées et fixant la liste de ces diplômes et des options et formations spécialisées transversales du troisième cycle des études de médecine. Journal Officiel 2017;28 avril (100).

53. American Academy of Neurology, Cerebrovascular Section, Society of NeuroInterventional Surgery, Society of Vascular and Interventional Neurology, Meyers PM, Schumacher HC*, et al.* Performance and training standards for endovascular ischemic stroke treatment. J Neurointerv Surg 2009;1(1):10-2.

54. Lenthall R, McConachie N, White P, Clifton A, Rowland-Hill C. BSNR training guidance for mechanical thrombectomy. Clin Radiol 2017;72(2):175 e11- e18.

55. European Society of Minimally Invasive Neurological Therapy, Cognard C, Szikora I. ESMINT statement regarding the UEMS training charter for interventional neuroradiology. EJMINT 2013;1327000117.

56. Berge J, Mounayer C, Vélasco S. Thrombectomie mécanique : quel avenir, quelles solutions (prise en charge, formation...) : exemple de la grande région Aquitaine, Limousin, Poitou-Charentes. 43me Congrès SFNR. J Neuroradiol 2016;43(2):67-8.

57. Campbell BC, Donnan GA, Lees KR, Hacke W, Khatri P, Hill MD*, et al.* Endovascular stent thrombectomy: the new standard of care for large vessel ischaemic stroke. Lancet Neurol 2015;14(8):846-54.

58. American Heart Association, American Stroke Association, Jauch EC, Saver JL, Adams HP, Jr., Bruno A*, et al.* Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2013;44(3):870-947.

59. Sheppard JP, Mellor RM, Greenfield S, Mant J, Quinn T, Sandler D*, et al.* The association between prehospital care and in-hospital treatment decisions in acute stroke: a cohort study. Emerg Med J 2015;32(2):93-9.

60. Gerschenfeld G, Muresan IP, Blanc R, Obadia M, Abrivard M, Piotin M*, et al.* Two Paradigms for Endovascular Thrombectomy after intravenous thrombolysis for acute ischemic stroke. JAMA Neurol 2017;74(5):549-56.

61. Hunsinger V, Moulin T. TéléAVC, un modèle de prise en charge. Tout Prévoir 2016;476.

62. Blanc-Labarre C, Delpont B, Hervieu-Begue M, Osseby GV, Ricolfi F, Thouant P*, et al.* Prise en charge aiguë des infarctus cérébraux en 2017. Rev Med Interne 2017.

63. Jadhav AP, Kenmuir CL, Aghaebrahim A, Limaye K, Wechsler LR, Hammer MD*, et al.* Interfacility transfer directly to the neuroangiography suite in acute ischemic stroke patients undergoing thrombectomy. Stroke 2017.

64. Convidien France. Solitaire ™ 2. Dispositif de revascularisation intracrânien. Partie II : dossier médico-technique. Boulogne-Billancourt: CF; 2016.

65. Stryker Neurovascular. Trevo® (XP) provue sur la liste des produits et prestations remboursables (article L 165-1 du CSS). Demande d'inscriptions des stents retrievers sur la liste des produits et prestations remboursables (Article L 165-1 du CSS). Rueil Malmaison: SN; 2016.

66. Agence régionale de santé Guadeloupe, Agence régionale de santé Martinique, Agence régionale de santé Guyane. Schéma interrégional d'organisation sanitaire Antilles Guyane 2015-2020. Gourbeyre; Fort de France; Cayenne: ARSG; ARSM; ARSG; 2014.

67. Agence régionale de santé Alsace. Schéma interrégional d'organisation des soins. Inter région est 2013-2018. Strasbourg: ARSA; 2013.

68. Agence régionale de santé Nord-Pas-de-Calais, Agence régionale de santé Basse-Normandie, Agence régionale de santé Haute-Normandie, Agence régionale de santé Picardie. Schéma interrégional d'organisation sanitaire pour l'interrégion Nord-Ouest, Nors-Pas-de-Calais, Picardie, Haute et Basse Normandie. 2014-2019. Euralille: ARS Hauts-de-France; 2014.

https://www.hauts-de-france.ars.sante.fr/lorganisation-interregionale-des-soins-dans-le-champ-sanitaire

69. Agence régionale de santé Bretagne, Agence régionale de santé Centre, Agence régionale de santé Pays de Loire, Agence régionale de santé Poitou-Charentes. Schéma inter régional d'organisation des soins SIOS 2014-2019. Inter région Grand Ouest. Bretagne, Centre, Pays de Loire, Poitou-Charentes. Rennes; Orléans; Nantes; Poitiers: ARSB; ARSC; ARSPL; ARSPC; 2014. http://www.bdsp.ehesp.fr/Base/490618/

70. Agence régionale de santé Rhône-Alpes, Agence régionale de santé d'Auvergne. Schéma inter-régional d'organisation sanitaire "Sud-Est" 2013-2018. Inter-région Rhône-Alpes-Auvergne. Lyon; Clermont-Ferrand: ARSRA; 2013. http://www.pieros.org/etude/schema-inter-regional-dorganisation-sanitaire-sud-est-2013-2018-inter-region-rhone-alpes-auvergne/

71. Agence régionale de santé Provence-Alpes-Cote d'Azur, Agence régionale de santé Languedoc-Roussillon, Agence régionale de santé Corse. Schéma interrégional d'Organisation des Soins. Inter région Sud Méditerranée Corse, Provence-Alpes-Cote-d'Azur, Languedoc-Roussillon 2014-2018. Marseille; Montpellier; Ajaccio: ARSPACA; ARSLR; ARSC; 2014. https://www.paca.ars.sante.fr/sites/default/files/2017-01/SIOS_version_publiee_RAA_2014_2018_arspaca_0.pdf

72. Agence régionale de santé Ile-de-France. Convention d'organisation territoriale de la prise en charge des pathologies neurologiques, neurochirurgicales, neuro radiologiques et neuro réanimatoires en Ile de France. « Recours à l'expertise neuro, en particulier par télémédecine" Paris: ARS IDF; 2015. https://www.iledefrance.ars.sante.fr/sites/default/files/2016-12/AVC-ORTIF_convention_annexes_Septembre_2015.pdf

73. Direction générale de l'offre de soins, Sous-direction de la régulation de l'offre de soins. Instruction n° DGOS/R2/2016/351 du 24 novembre 2016 relative à l'actualisation du diagnostic des populations situées à plus de trente minutes d'un accès aux soins urgents. Bulletin Officiel Santé 2016;2016-12.

74. Société française de Neuroradiologie. Etat des lieux et carte interactive [En ligne] 2016. http://www.sfnr.net/neuroradiologie-quotidien/thrombectomie/la-thrombectomie/etat-lieux-carte-interactive

75. Siegel J, Pizzi MA, Brent Peel J, Alejos D, Mbabuike N, Brown BL*, et al.* Update on neurocritical care of stroke. Curr Cardiol Rep 2017;19(8):67.

76. Mokin M, Snyder KV, Siddiqui AH, Levy EI, Hopkins LN. Recent Endovascular Stroke Trials and their impact on stroke systems of care. J Am Coll Cardiol 2016;67(22):2645-55.

77. Turc G, Maier B, Naggara O, Seners P, Isabel C, Tisserand M*, et al.* Supplemental material : Clinical scales do not reliably identify acute ischemic stroke patients with large-artery occlusion. Stroke Res Treat 2016;47(6):1466-72.

78. Turc G, Maier B, Naggara O, Seners P, Isabel C, Tisserand M*, et al.* Clinical scales do not reliably identify acute ischemic stroke patients with large-artery occlusion. Stroke 2016;47(6):1466-72.

79. McTaggart RA, Yaghi S, Cutting SM, Hemendinger M, Baird GL, Haas RA*, et al.* Association of a primary stroke center protocol for suspected stroke by large-vessel occlusion with efficiency of care and patient outcomes. JAMA Neurol 2017;74(7):793-800.

80. Schlemm E, Ebinger M, Nolte CH, Endres M, Schlemm L. Optimal transport destination for ischemic stroke patients with unknown vessel status: Use of prehospital triage scores. Stroke 2017;48(8):2184-91.

81. Zaidi SF, Shawver J, Espinosa Morales A, Salahuddin H, Tietjen G, Lindstrom D*, et al.* Stroke care: initial data from a county-based bypass protocol for patients with acute stroke. J Neurointerv Surg 2017;9(7):631-5.

82. Guillon B, Bourcier R, Toulgoat F, de Gaalon S, Gaultier-Lintia A, Sévin M. Prise en charge de l'infarctus cérébral aigu Neurologie 2016;13(3):1-23.

# Fact sheet

| Title | Description |
|---|---|
| Work method | Health technology assessment |
| Date of on-line publication | July 2018 |
| Date of issue | Only available in electronic format at www.has-sante.fr |
| Purpose(s) | Assessment of organisational aspects of mechanical thrombectomy in France |
| Professional(s) concerned | *Cf.* section 3.3.1 |
| Requested by | Ministry of solidarity and health, Directorate General of Health Care Provision (DGOS) |
| Sponsor | French National Authority for Health (HAS), Diagnostic and therapeutic procedure assessment department (SEAP) |
| Project management | Coordination: Huguette LHUILLIER-NKANDJEU, project lead, SEAP (Head of Department: Cédric CARBONNEIL, Assistant Head of Department: Nadia ZEGHARI-SQUALLI)<br>Secretarial duties: Louise TUIL, assistant, SEAP |
| Participants | External HAS review (assessment report review):<br>"Endovascular mechanical thrombectomy for the treatment of stroke" Ministerial Steering Committee<br>*Cf.* Section 3.3 |
| Documentary search | October 2010 to October 2017 (documentary search strategy described in appendix 1) with monitoring until April 2018.<br>Conducted by the archivist Emmanuelle BLONDET, assisted by the assistant archivist Maud LEFEVRE, under the responsibility of Frédérique PAGES, Head of Documentation - Monitoring Department, and Christine DEVAUD, Assistant Head of Department |
| Authors of justification | Huguette LHUILLIER-NKANDJEU, project lead, SEAP, under the responsibility of Nadia ZEGHARI-SQUALLI, Assistant Head of Department, and Cédric CARBONNEIL, Head of Department, SEAP |
| Approval | Review by the National Committee for the Evaluation of Medical Devices and Health Technologies (CNEDiMTS): June 2018<br>HAS College: July 2018 |
| Other formats | No formats other than the electronic format available in www.has-sante.fr |
| Accompanying documents | Framework document, abridged technological assessment report, HAS ruling (June 2018) available at www.has-sante.fr |

~

"All HAS publications can be downloaded from"
**www.has-sante.fr**