Mechanical thrombectomy practices in France: Exhaustive survey of centers and individual operators

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Abstract

Background and purpose: Mechanical thrombectomy (MT) has dramatically changed the landscape of stroke care as well as stroke care organization. Public health institutions are faced with the challenge of swiftly providing equal access to this high technical level procedure with rapidly broadening indications, and constantly developing techniques. The aim of this study was to present a current nationwide overview of technical MT practices in France as well as local organizations.

Materials and methods: Thrombectomy capable French stroke centers, and physicians performing MT were invited to participate to a nationwide survey, disseminated through an existing trainee-led research network (the JENI-RC) under the aegis of the French Society of Neuroradiology. The survey was composed of 64 questions to collect both individual practices and general center-based information.

Results: All French centers (100 %) answered the survey, and 74% (110/148) of active interventional neuroradiologists (INR) performing MT completed individual questionnaires. The mean number of INR per center performing MT was 3.7±1.85, and 85% of the centers were organized for 24/7 continuity of care. MRI was the most commonly used imaging modality for stroke diagnosis and patients' selection, and perfusion imaging was routinely available in 85% of the centers. Half of centers performed yearly between 100 and 200 MT. Anesthesiologic, and technical considerations are also developed in the manuscript.

Conclusions: This nationwide survey highlights the impressive response to the challenge of reorganization of stroke care with regards to mechanical thrombectomy in France. Technical and management disparities remain. Most centers remain understaffed to properly function in the long term, but the inflow of INT trainees is substantial.

Abbreviations

AIS, acute ischemic stroke; ASPECTS, Alberta stroke program early CT score; DWI, Diffusion weighted imaging; INR, Interventional neuroradiologist; JENI, Jeunes en neuroradiologie interventionnelle; LVO, Large vessel occlusion; MRS, Modified Rankin Scale; MT, Mechanical thrombectomy; NIHSS, National Institutes of Health Stroke Scale; PWI, Perfusion weighted imaging; SFNR, French Society of Neuroradiology; TCSC, Thrombectomy-capable stroke center.

Keywords

Stroke; Thrombectomy; Endovascular; Report; Survey

Introduction

Mechanical thrombectomy (MT) has dramatically changed the landscape of stroke care as well as stroke care organization for patients with acute ischemic stroke (AIS) due to large vessel occlusion (LVO). [1,2]. Public health institutions have been faced with the challenge of swiftly providing equal access to this high technical level procedure. In this context, beyond the complexity of regional stroke networks, and care chain at play to maximize the number of AIS-LVO patients receiving MT, this shift has importantly increased the workload at thrombectomy-capable stroke centers (TCSC), prompting local reorganization, mandating staff increase, and the opening of new MT capable centers in previously depleted areas so as to minimize delays to treatment and best fit to regional specificities. Further, indications have broadened and technical developments likely led to changes in individual practitioner's approaches to patients' selection, technical strategies for revascularization, as well as peri-procedural management, but these changes remain undocumented in real word environments. Altogether there is a lack of informative large-scale data on technical practices and centers' organization with regards to MT after guidelines modifications, while they may positively inform institutions, and provide a framework for improvement both logistically, for training planification and in terms of adherence to best practices.

The aim of this study was thus to present a current nationwide overview of technical MT practices in 2018-2019 in France, local organizations, and to compare these results with a previous survey conducted in 2012.

Materials and methods

Using the collaborative research network 'Jeunes en Neuroradiologie Interventionnelle' [3], and under the aegis of the French Society of Neuroradiology (SFNR), a survey was sent in January 2019 to a delegate physician, member of the network, at every TCSC in France.

The survey was based on the one used in 2012 and reported by Soize et al.[4], and included new questions to better fit to advances in stroke treatment and indications evolutions.

The survey was written in French and divided into two independent questionnaires:

- a questionnaire for each practitioner performing thrombectomy in autonomy, to collect individual responses about patient's selection and endovascular procedures
- a second questionnaire to collect general center-based informations regarding mechanical thrombectomy cases volume in 2018, imaging modalities used for patients' selection, anesthetic management, technical specificities, imaging follow-up, and unit organization

The final survey comprised a set of 64 questions, divided into 3 subheadings and is presented in the supplementary material.

Statistical analysis was performed with MedCalc.net statistical website (© 2019 MedCalc Software): https://www.medcalc.net

Results

Between January 1st, 2019 and April 2019, we received responses from all French TCSC (40/40), and individual responses from 74 % (110/148) of senior interventional neuroradiologists (INR) working in France. Complementary data for each sub chapter is available in the Appendix of the supplemental material.

Case volume, centers, and teams

During the year 2018, a total of 6 704 MT procedures were reported in 38 centers (2 TCSC with less than 50 MT were excluded because accurate case volume was not recorded). The mean number of MT performed by TCSC was 176.4±115.4, median 147.

Mechanical thrombectomy was available around the clock in 34/40 institutions (85%). Two centers (5%) had a convention with a distinct TCSC to provide treatment during off-hours.

The mean number of INR qualified for MT procedures per center was 3.7±1.85, median 4. Thirteen TCSC (13/40, 32.5%) teams comprised 1or 2 INR to perform MT, 16 TCSC (40%) had 3 or 4 INR involved, and 11 TCSC (27.5%) had more than 4. The total number of INR performing MT in France was 148, representing 134.6 full-time INR (and among them, 110 answered the questionnaire).

Twenty-eight TCSC (28/40, 70%) used a single angio-suite dedicated to neuro-interventional procedures, or two angio-suites (7/40, 17.5%), or three (1/40, 2.5%), and 4 TCSC (4/40, 10%) shared the angio-suite with other specialties during working hours. Off hours local organizations were more mixed.

Correspondents were asked how many additional practitioners they required to ensure actual and future needs for MT: 12/40 TCSC (30%) needed 1 more INR, 18 TCSC (45%) needed 2 more INR, 3 TCSC (7.5%) needed 3 more INR, and 1 TCSC (2.5%) needed 5 more INR for a total of 62 additional INR needed. Six TCSC (15%) declared being adequately staffed. At the time of the survey, 90% of TCSC had trainees (fellows or INR residents), including 21/40 TCSC (52.5%) training 1 or 2 INR, 10/40 TCSC (25%) training 3 or 4 INR, 5/40 TCSC (12,5%) training ≥ 5 INR, for a total of 91 INR in training, of which 57 intended to work in France after training completion.

Patients selection and imaging follow-up

MRI was the most commonly used imaging modality (34/40 TCSC, 85%) for screening patients with suspected acute stroke, while 6 TCSC (6/40, 15%) used CT. Among MRI users: 13/34 TCSC (38.2%) used 1.5T MRI, 13/34 TCSC (38.2%) used 3T MRI, and 8/34 TCSC (23.6%) used both 1.5 and 3T MRI. Concerning these centers, protocols were the same in routine with DWI, FLAIR, intracranial TOF-MRA. Variations were observed for the use of specific sequences: T2* (27/34, 79.4%), susceptibility-weighted MR sequences (7/34, 20.6%), T2*-weighted perfusion imaging (12/34, 35.3%), cervical MRA (21/34, 61.8%), or ASL perfusion (1/34, 2.9%). The majority of the TCSC (25/34, 73.5%) performed MRI stroke protocol in less than 15 minutes, and between 15 and 20 minutes for 9/34 TCSC (26.5%).

For the 6 TCSC using CT, protocol was similar including cervical vessels CTA and CT perfusion. Two TCSC (2/6, 33.3%) routinely acquired a heart CT searching for cardiac thrombus.

INR were asked what clinical and/or imaging data led them to decline MT among 15 proposals (see details in Table 1). Two exclusion criteria were exceeding the average: previous autonomy loss (mRS > 2) (65/106, 61.3%) and hemorrhagic transformation (61/106, 57.5%). Most of them were keen to perform MT regardless of delay since onset, as long as there was a persistent diffusion/clinical mismatch (74/110, 67.3%) or DWI/PWI mismatch (64/110, 58.2%).

Follow-up imaging was dominated by 24 hours CT (see details of follow up imaging modalities in Figure 1).

Endovascular procedure

Most of the TCSC (36/40, 90%) had an anesthetic team available anytime. For anterior circulation, most TCSC started procedures with conscious sedation secondary switched into general anesthesia if needed according to the clinical situation for carotid occlusion (15/40, 37.5%), or middle cerebral artery occlusion (17/40, 42.5%). Only 14 TCSC (35%) and 10 TCSC (25%) used systematic general anesthesia for carotid occlusion or middle cerebral artery occlusion respectively.

Conversely, for basilar artery occlusion 21/40 TCSC (52.5%) started procedures directly with general anesthesia, or with conscious sedation secondary turned into general anesthesia 13/40 (32.5 %) detailed in Figure 2.

When starting MT procedure, most of INR (98/110, 89.1%) explored only the occluded vessel, while 12 INR (10.9 %) evaluated the whole intracranial circulation. In case of catheterization failure through femoral artery, INR chose different approaches resumed in Figure 3.

Eighteen INR (16.4%) used a balloon guide catheter for all procedures, and 39 (35.5%) never used it. The majority of INR (60/110, 54.5%) used combined stent-retriever with distal aspiration catheter as first line approach, while 27.3% and 18.2% used aspiration or stent-retriever respectively.

Only 28/110 INR (25.5%) used intra-arterial fibrinolysis following a thrombectomy: to treat distal embolization (23/28, 82.1%), in case of MT failure (9/28, 32.1%), or systematically (2/23, 8.7%).

During MT, 88 INR (88/110, 80%) did not use heparin, while 15 (13.6%) used a single bolus and 7 (6.4%) used a bolus with a maintained dose.

Comparison with 2012 survey

We were unable to perform formal statistical analyses to compare the results of 2012 and the current survey, as data elements were not acquired in a similar way (center versus operator). Yet, several important differences in practices stand out in numerical comparisons.

First, in 2012 the median number of MT performed at each center was 30 [IQR: 17—43], versus 147 [IQR: 101-248] in 2018, representing a fivefold increase. Conversely, the mean number of INR performing MT at each center only increased from a mean 2.9± SD 0.9 to 3.7±1.8.

Regarding more technical aspects, notably the routine use of perfusion imaging increased from 42% to 76% and operators were more systematically switching to a second (rescue) device after failed attempts with a first device (48% in 2012 versus 81% in 2018). Detailed comparative assessment is provided in Table 2.

Discussion

Here we highlight several key aspects of the real-world response to the challenge posed by MT at a national level, as well as the evolution of practices and local organizations at TCSC, and present a snapshot of MT practices for the year 2018 at a nationwide level in France.

The validation and resulting considerable increase in MT procedures volumes between the first national survey of MT practices reported in 2014 [4], has led to major local re-organizations, case approaches changes and standardization. According to national statistics and the results of the present study, MT procedures have increased seven fold between 2012 and 2018 (925 > 6704) [4], and more than 20% between 2017 and 2018. Since 2012, time of the previous survey, 7 additional TCSC have opened, leading up to 40 TCSC, but the number of INR qualified for MT remains low in most centers (3.7±1.85, median 4), resulting in a high case volume per operator (45.8±19.4, median 41,9) and an insufficient increase in the number of trained INR performing MT. This explains the fact that only 15% of centers declared being adequately staffed at the time of survey while MT remains a complex procedure with the majority of INR (60/110, 54.5%) using combined stent-retriever with distal aspiration catheter as first line approach. To our knowledge, no such data have been published from other countries, yet the global challenge of stroke care re-organization makes it likely that similar disparities and shortage in trained physicians exist worldwide. On a very positive note, 90% of centers were actively training at least one or two future INR, and 37.5% trained 3 or more, emphasizing the globalized response to the challenge of MT in France, with an increased projection of a 38% increase in the workforce at existing centers, in the 2 coming years only.

Formal statistical analyses cannot be performed when comparing declarative data from individual practitioners regarding MT practices, or general data on routine selection and organization methods at the center level. Yet, it is important to note that 85% of the TCSC used MRI versus only 64% in 2012, underlying a better organization for access to acute MRI in France, despite relative low national dotation.

Improvements in patients' selection pathways are also reflected by the higher routine availability of perfusion imaging, especially among MRI users (82.9%, 29/35 versus 35.5%, 11/31 in 2012), a result

that should be put in the perspective of the fact that responses were registered before the publication of updated guidelines for patients in the extended time window [5–8].

In that sense, patients' selection was per the results of this survey largely based on expected benefit of mechanical revascularization, rather than strict applications of minimal standards for indication set by international guidelines, and reflecting the diversity of real-world practices. For instance, time delay since onset of symptoms was not a major determinant for declining MT, since most of INR reported that they did not decline MT when there was clinical mismatch (67.3%) or DWI-PWI mismatch (58.2%) regardless of delay since symptoms onset while it was respectively 16.1% and 9.7% of TCSC in 2012.

In the survey, four predominant situations were perceived as a non-indication for endovascular treatment by operators: previous autonomy loss (mRS > 2) (61.3%), hemorrhagic transformation (57.5%), no DWI-PWI mismatch (45.3%), and midline displacement (44.3%).

A limitation of this study is that declarations of the respondents cannot be controlled, and a single INR per center was designated to complete the online questionnaire for collecting general center based informations. This potential bias is limited by the use of protocols and standardization of MT at most TCSC. Also, we were unable to include patients' radiation exposure during MT. Future studies comparing MT in France should include dosimetry comparison, while MT is not yet included in the last French Diagnostic Reference Levels of the 23 May 2019 [9-10].

Furthermore, the results of this survey present a snapshot of MT practices in France at a specific time point and might be different at the time of results publication.

Conclusions

This survey, with an exhaustive response rate of 40/40 TCSC (100%) and 74.3% of INR (110/148) provides a snapshot of MT practices and adherences to guidelines by interventional neuroradiologists in France. Further, it yields a framework for appreciating local needs, regional organizations and national training and position needs at thrombectomy capable centers. Future efforts should be aimed at opening more senior positions at active TCSCs, so as to ensure long term sustainability and adequate staffing.

Disclosures

The authors declare that they have no conflicts of interest concerning this article.

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Figures

Figure 1: Imaging modalities for follow-up after MT for AIS

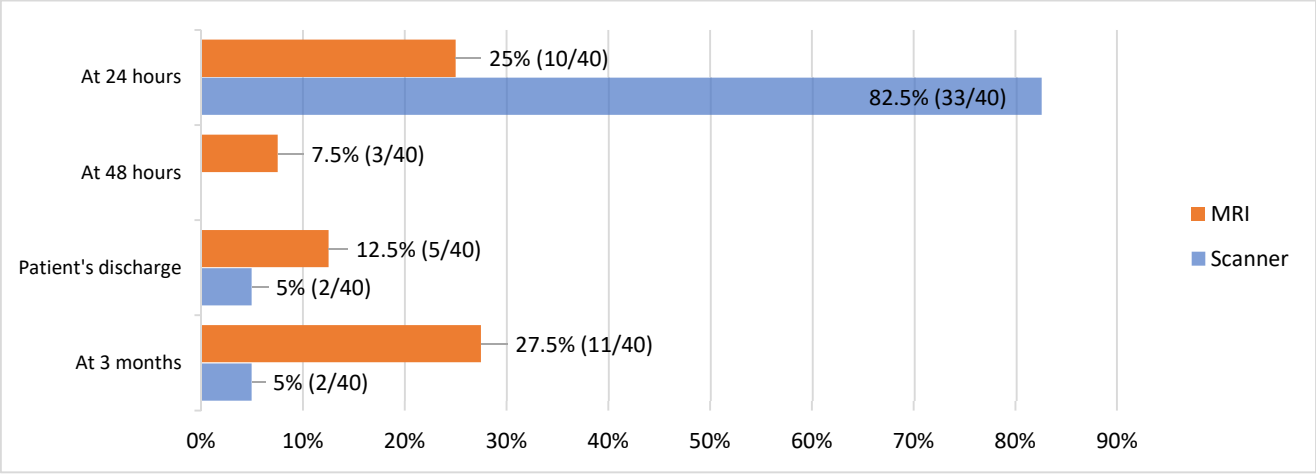


Figure 2: Anesthetic considerations according to occlusion localization

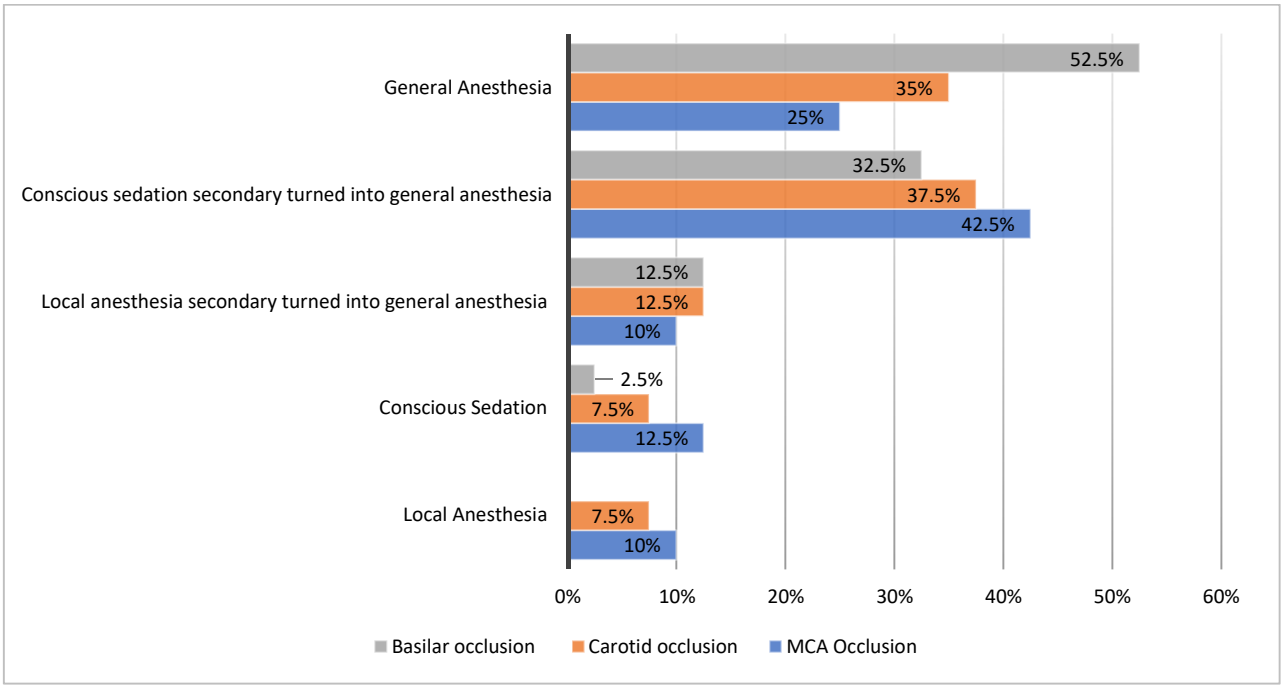
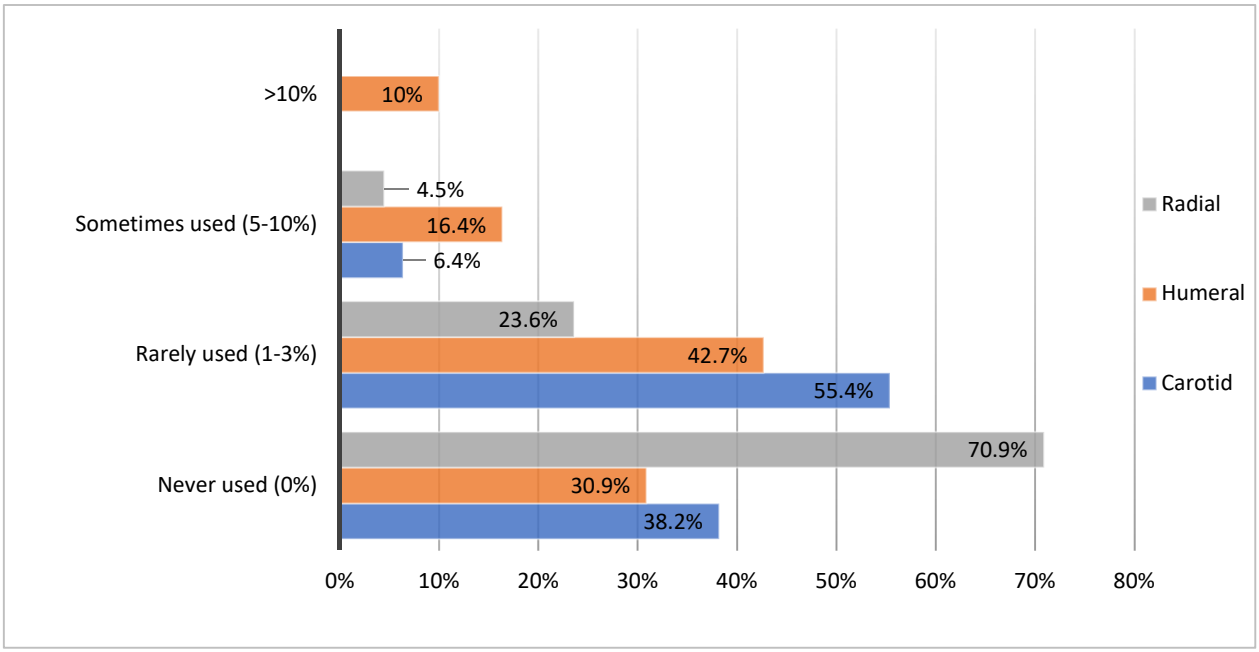


Figure 3: Proportion of arterial access used for MT per practitioner



Facing a difficult femoral approach, or a difficult carotid catheterization, what percentage of cases do you use carotid, humeral or radial approach for MT?

Tables

Table 1: Non-indication of the endovascular treatment of acute ischemic stroke according to INR

Parameters	**Number of positive responses**	**Percentage (%)**
Clinical examination		
Low NIHSS (i.e. < 3 — 5)	32	30.2
High NIHSS (i.e. > 25)	3	2.8
Age > 90 years	4	3.8
Previous autonomy loss (mRS > 2)	65	61.3
Imaging finding		
ASPECTS on DWI < 5	22	20.8
ASPECTS on CT < 6	16	15.1
Volume > 70 cm^3 on DWI	9	8.5
Flair positivity	12	11.3
No DWI-PWI mismatch	48	45.3
Haemorrhagic transformation	61	57.5
Severe leukoaraiosis	1	0.9
Tandem occlusion	0	0
Carotid T occlusion	0	0
Midline displacement	47	44.3
Other	4	3.8

Table 2: Comparison of 2012 and 2018 similar data elements

	2012		2018	
	N	**Percentage**	**N**	**Percentage**
Response rate	31/33	93.9	40/40	100
MT around the clock	25/31	80.6	34/40	85
Mean number of INR performing MT	2.9±0.9, median 3		3.7±1.85, median 4	
Mean number of MT per center	Median 30 [IQR : 17-43]		Median 147 [IQR : 101-248]	
Number of centers using only MRI	20/31	64.5	34/40	85
Cervical MRA in routine	11/31	35.5	21/34	61.8
T2*-weighted perfusion imaging in routine	11/26	42.3	26/34	76.5
Cervical vessels CTA in routine	10/11	90.9	6/6	100
CT perfusion in routine	9/11	81.8	6/6	100
No delay for MT in case of DWI-PWI mismatch (anterior circulation)	3/31	9.7	64/110	58.2
No delay for MT in case of diffusion/clinical mismatch (anterior circulation)	5/31	16.1	74/110	67.3
Up to 24 hours for MT (Posterior circulation)	9.5/31	30.6	53/110	48.2
Dedicated anesthesia team available anytime	27/31	87.1	36/40	90
Bridging approach	11/31	35.5	34/40	85
Use of a second device when MT failed with the first device	15/31	48.4	88/108	81.5
Use of a balloon-catheter	17.5/31	56.5	71/110	64.5
Assessment of the whole intracranial circulation at the beginning of MT	11/31	35.5	12/110	10.9
Use of heparin during MT	16.5/31	53.2	22/110	20
Use of intra-arterial fibrinolysis following a MT	16/31	51.6	28/110	25.5

Graphical abstract

Not applicable.