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# Results of early versus delayed carotid surgery after acute ischemic stroke

Sébastien Perou

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Année : 2015

FACULTE DE MEDECINE DE GRENOBLE

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THESE

PRESENTEE POUR L'OBTENTION DU DOCTORAT EN MEDECINE

DIPLÔME D'ETAT

**PEROU SEBASTIEN**

Né le 17 Octobre 1986 à REIMS

THESE SOUTENUE PUBLIQUEMENT A LA FACULTE DE MEDECINE DE GRENOBLE\*

Le 24 Avril 2015

Devant le jury composé de :

Monsieur le **Professeur MAGNE Jean-Luc** : Président du jury et Directeur de thèse

Monsieur le **Professeur BRICHON Pierre-Yves**

Monsieur le **Professeur CHAFFANJON Philippe**

Monsieur le **Docteur DETANTE Olivier**

Monsieur le **Docteur COCHET Emmanuel**

*\*La Faculté de Médecine de Grenoble n'entend donner aucune approbation ni improbation aux opinions émises dans les thèses ; ces opinions sont considérées comme propres à leurs auteurs.*



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## Remerciements

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*Les anesthésistes ; Bruno tantôt râleur tantôt blagueur, Luis mon péruvien préféré, Martine et ses hypnoses, Anne-Caroline, Thierry, tous nos AR de Réa 9 et les IADE.*

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## Résumé

**Titre** : Résultats du traitement chirurgical précoce et tardif des sténoses carotidiennes symptomatiques responsables d'infarctus cérébral.

**Objectif** : Evaluer les résultats des patients opérés d'une sténose carotidienne symptomatique responsable d'un infarctus cérébral, après une revascularisation précoce (< 14 jours) ou tardive (de 14 jours à 3 mois).

**Méthodes** : Etude rétrospective monocentrique incluant tous les patients ayant bénéficié d'une chirurgie carotidienne dans les 3 mois après un infarctus cérébral de Juillet 2010 à Juin 2014. Le Groupe A concernait les patients qui ont bénéficié d'une revascularisation dans les 14 premiers jours après le début des symptômes et le Groupe B ceux qui ont été opérés entre 15 jours et 3 mois après le début des symptômes. La mortalité, le taux d'infarctus cérébral et les complications cardiaques post-opératoires ont été analysés.

**Résultats** : Soixante et onze patients ont été opérés d'une sténose carotidienne symptomatique avec un infarctus cérébral (73.2% d'hommes, âge médian de 71 ans). Dix-neuf patients ont été opérés précocement avec un délai moyen de prise en charge chirurgicale de 9.5 jours [3-14] et 52 ont été opérés tardivement avec un délai moyen de prise en charge chirurgicale de 42 jours [15-92]. Le suivi à un mois de 98.6% des patients, n'a montré dans le groupe A aucune complication post-opératoire ; et 2 hématomes cérébraux (3.8%) responsables d'AVC dans le groupe B.

**Conclusion** : Cette étude confirme le résultat satisfaisant des revascularisations carotidiennes précoces après infarctus cérébral. Une sélection clinique et radiologique rigoureuse des patients permet d'éviter les complications neurologiques précoces.

**Mots-clefs** : sténose carotidienne, symptomatique, revascularisation précoce, résultats.

## **Abstract**

**Title:** Results of early versus delayed carotid surgery after acute ischemic stroke.

**Objective:** Evaluate the 30-day outcomes of patients with an internal carotid artery (ICA) stenosis responsible for an acute brain infarction who underwent early ( $\leq 14$  days) or delayed (15 days to 3 months) carotid endarterectomy (CEA).

**Methods:** From July 2010 to June 2014, we studied all patients with a recent cerebral infarction who underwent CEA within 3 months after the onset of symptoms. This was a continuous, monocentric, and retrospective series. Two groups were identified: Group A with patients who underwent CEA in the first fourteen days after symptom onset; and Group B with patients who underwent CEA from the fifteenth day to the third month after symptom onset. Death, stroke and major cardiac events were analyzed.

**Results:** Seventy-one patients with ICA stenosis responsible for an acute brain infarction underwent CEA (73.2% men, with a median age of 71). Nineteen patients underwent early CEA and 52 underwent delayed CEA. The mean interval from initial examination to surgery was 9.5 days (range, 3-14 days) in Group A and was 42 days (range, 15-92 days) in Group B. After one month, and with a 98.6% follow-up, no postoperative complication occurred in Group A and 2 patients in Group B had a post-operative stroke (3.8%).

**Conclusion:** This retrospective study confirms the satisfactory outcomes of early CEA after acute brain infarct. A strict clinical and radiological selection of patients prevents early neurological complications.

**Keywords:** carotid stenosis, early surgery, results, brain infarct.



## **Introduction**

Stroke management is a public health issue. The establishment of stroke units and increased accessibility to high-performance brain imaging have improved the immediate care of patients presenting acute neurologic focal deficit. When significant carotid stenosis is responsible for neurologic symptoms, surgical care is recommended.<sup>1-3</sup> Nevertheless, the timing from symptom onset to surgery is a key question. Indeed, early carotid revascularization decreases the risk of stroke recurrence, but can be complicated by a new cerebral infarction or of the hemorrhagic transformation of the preexisting ischemic lesion. Many randomized trials have shown the benefit of early carotid revascularization for symptomatic carotid stenosis in stable patients<sup>4</sup>. According to the recent literature, carotid endarterectomy (CEA) is recommended within the first two weeks of a transient ischemic attack (TIA) or minor stroke,<sup>5-8</sup> or even in the hyper-acute period (within the first 48h).<sup>9-10</sup> In contrast, for major stroke or strokes in evolution, the main studies recommend that surgery should be delayed until 4 to 6 weeks after the first neurological symptoms, and to perform surgery when the clinical and radiological lesions have stabilised.<sup>11-12</sup> However, some recent series have questioned the purpose of delaying revascularization, showing excellent outcomes after early revascularization during the acute phase of major stroke.<sup>13-15</sup> The main objective of our study was to evaluate the 30-day outcomes of patients who underwent early or delayed CEA in our department after an acute brain infarction due to internal carotid artery (ICA) stenosis.

## Methods

**Study design.** This was a descriptive retrospective single-center study of the outcomes of CEA after acute ischemic stroke in Grenoble University Hospital. We consulted the vascular surgery database from July 2010 to June 2014 and extracted data on all patients who had undergone carotid revascularization. Patients with asymptomatic carotid stenosis or with CEA combined with cardiac bypass surgery were excluded. For patients with a symptomatic carotid stenosis, we cross-referenced the vascular surgery database with the stroke unit database. For all patients, brain images were studied and patients who had suffered TIA were excluded. Thus, we obtained a continuous series of patients who underwent CEA after a recent stroke and we retained only those who had been operated in our department during the first 3 months after symptom onset. Data collected included demographics, medications, neurologic presentation (symptom onset, neurologic deficit and NIHSS score at admission, evolution of symptoms), radiologic findings (carotid duplex ultrasound imaging and brain imaging), preoperative workup, operative details, complications, and clinical and ultrasound imaging follow-ups at 1 and 3 months. Primary outcomes were 30-day postoperative mortality, stroke, and the rate of cardiac complications.

**Definitions.** An internal carotid artery (ICA) stenosis was symptomatic when it caused a focal neurologic deficit corresponding to the territory of the lesion considered. We defined a single transient ischemic attack (TIA) as a focal neurologic deficit lasting < 1 hour without any recent ipsilateral lesion on brain imaging. We defined a stroke as a focal neurologic deficit associated with a radiologic lesion in the brain territory concerned. We prefer to use the term brain infarct rather than stroke to describe

radiologic lesions in order to differentiate ischemic lesions from hemorrhagic lesions. The cohort was divided in two groups. Group A included all patients who underwent CEA in the first 14 days after symptom onset. Group B gathered patients who underwent CEA from day fifteen to three months after the initial examination.

**Emergency diagnostic workup.** Patients received standardized preoperative care. At admission, a neurologic evaluation was immediately performed by a neurologist who described symptoms with their severity and duration. The NIHSS score was always calculated or recalculated using the initial complete neurologic description for patients secondarily transferred to the university hospital. Brain imaging (CT scan or MRI) was systematic to confirm the diagnosis and to rule out a hemorrhagic infarction. In case of hemorrhagic lesion, second control brain imaging was performed. Patients were hospitalized in the stroke unit and received optimal medical therapy with antiplatelet agents and statins. Eligible patients received thrombolytic therapy. Duplex ultrasound imaging combined with CT or MR angiography was used for the diagnosis of ICA stenosis (> 60% according to the North American Symptomatic Carotid Endarterectomy Trial<sup>11</sup> criteria). After diagnosis, if the patient showed clinical improvement with no sign of hemorrhage or massive stroke on brain imaging he was referred to the vascular surgery team to confirm the indication and timing of CEA.

**Operative procedure and outcomes.** The operative procedure was always performed under general anesthesia with a standardized surgical technique. Blood pressure was monitored by invasive blood pressure measurement. Heparin (50 IU/kg intravenously) was administered before clamping. Shunting was used if the residual pressure was < 50mmHg or if low reflux in the internal carotid artery was observed. Carotid duplex ultrasound imaging was systematically realized by the operator at the end of the

revascularization. In the recovery room, blood pressure was checked every 15 minutes and hypertension > 16mmHg was treated. Postoperative hospitalization was in the vascular surgery department and neurologic evaluation was routinely repeated. A new persistent neurologic deficit with concordant brain imaging was classified as a new stroke. A major cardiac event was defined as thoracic pain associated with an ischemic change in the electrocardiogram and an elevated troponin concentration. Follow-up neurologic examinations were performed by the vascular surgeon at 1 and 3 months and by the neurologist at 6 months. After discharge, all patients were scheduled for carotid duplex ultrasound imaging at 3 months.

**Statistical analysis.** Results are expressed as means and standard deviations or as median and interquartile range (IQR) as appropriate. Statistical analysis was performed using the Wilcoxon-Mann-Whitney test, the Chi<sup>2</sup> test or, when appropriate, the Fisher exact test. Significance was assumed at  $p < 0.05$ .

## Results

From July 2010 to June 2014, 447 patients (154 symptomatic patients (34.4%) and 293 asymptomatic patients) were treated for carotid disease in the vascular surgery department of Grenoble University Hospital. Patients with combined CEA and cardiac bypass surgery were excluded. Among symptomatic patients, clinical presentation was TIA in 61 patients (39.6%) and stroke in 93 patients (61.4%). Among these 93 patients, we excluded 22 for whom the onset of symptoms was more than three months prior to CEA. In total, 71 consecutive patients who had undergone CEA after an acute ischemic stroke were eligible for our study. Nineteen patients underwent surgery within the first fourteen days (Group A) and 52 patients were treated between day fifteen and 3 months (Group B).

**Patient characteristics.** The study population was composed of 52 men (73.2%) and 19 women (26.8%), and their median age at presentation was 71 years (IQR, 65-78 years). The two groups did not significantly differ in age and sex (**Table I**). The prevalence of cardiovascular risk factors such as smoking, diabetes, obesity or hypercholesterolemia was similar across groups. Group B showed a significantly higher proportion of patients with systemic hypertension (80.8% vs 57.9%;  $p = 0.05$ ). Demographic characteristics are presented in **Table I**.

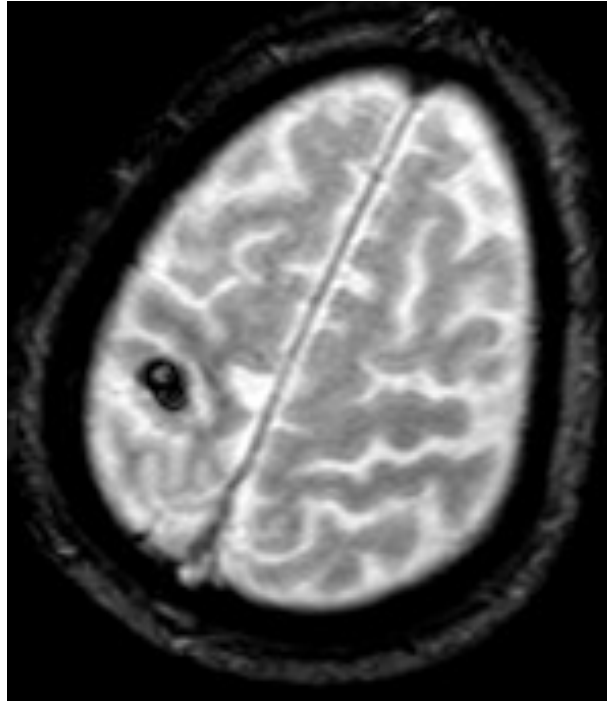
**Table I.** Baseline characteristics and medical history.

<i>Variables<sup>a</sup></i>	<i>Total n = 71</i>	<i>Group A n = 19</i>	<i>Group B n = 52</i>	<i>p</i>
Age, years	71 [65 ; 78]	69 [65 ; 79]	71.5 [65.5 ; 78]	0.90
Male sex	52 (73.2)	16 (84.2)	36 (69.2)	0.21
Smokers (current/former)	47 (66.2)	15 (78.9)	32 (61.5)	0.17
Hypertension	53 (74.6)	11 (57.9)	42 (80.8)	0.05
Hypercholesterolemia	39 (54.9)	10 (52.6)	29 (55.8)	0.81
Diabetes	22 (31)	4 (21.1)	18 (34.6)	0.27
Obesity (BMI > 30)	9 (12.7)	2 (10.5)	7 (13.5)	0.74
Chronic lung disease	14 (19.7)	3 (15.8)	11 (21.2)	0.61
Renal impairment	6 (8.5)	1 (5.3)	5 (9.6)	0.56
Atrial fibrillation / valvular heart disease	6 (8.5)	2 (10.5)	4 (7.7)	0.70
Coronary artery disease	18 (25.4)	7 (36.8)	11 (21.2)	0.18
Previous stroke or TIA	14 (19.7)	5 (26.3)	9 (17.3)	0.40
American Society of anesthesiologists				0.59
Grade I	1 (1.4)	0	1 (1.9)	-
Grade II	19 (26.8)	7 (36.8)	12 (23.1)	-
Grade III	50 (70.4)	12 (63.2)	38 (73.1)	-
Grade IV	1 (1.4)	0	1 (1.9)	-
Optimal medical therapy (antiplatelet + statin)	26 (36.6)	8 (42.1)	18 (34.6)	0.56

BMI, Body Mass Index ; TIA, transient ischemic attack.

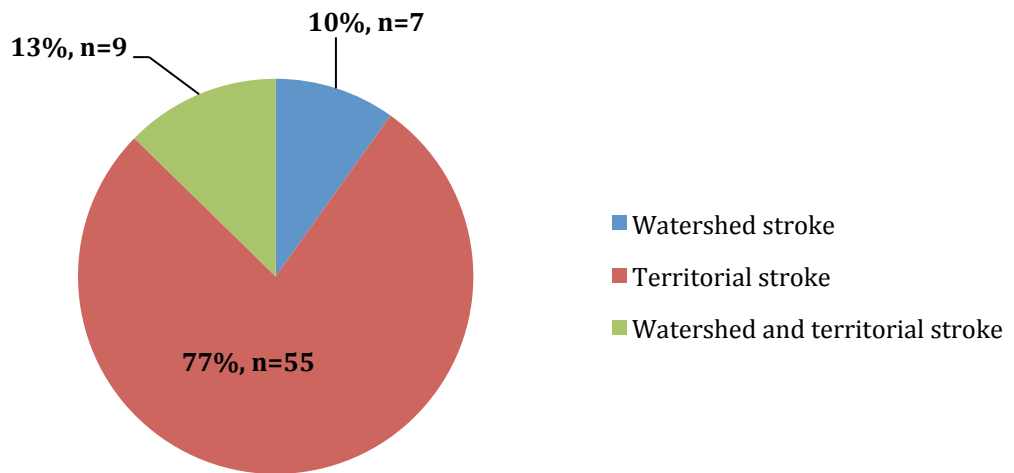
<sup>a</sup>Categorical data are shown as number (%) and continuous data as median [Q1 ; Q3].

**Peri-operative management.** At admission, the mean NIHSS score in Group B was significantly higher than in Group A (5 [range, 0-27] vs 3 [range, 0-7] respectively;  $p = 0.04$ ) and in 3 patients the NIHSS score was >15 with a major neurologic deficit. All patients underwent brain imaging: 56 had MRI and 15 had CT scans. All patients had sustained one or more recent ischemic infarcts < 3cm in the appropriate hemisphere. MRI was more often performed in Group A (89.5% vs 75%;  $p = 0.32$ ) but the difference was not significant. **Figure 1** illustrates imaging evaluation in a 87-year-old man with a left hemiplegia (NIHSS score 6 at admission) who underwent surgery 15 days after onset of symptoms, after a control brain MRI because of a hemorrhagic lesion in this first image.

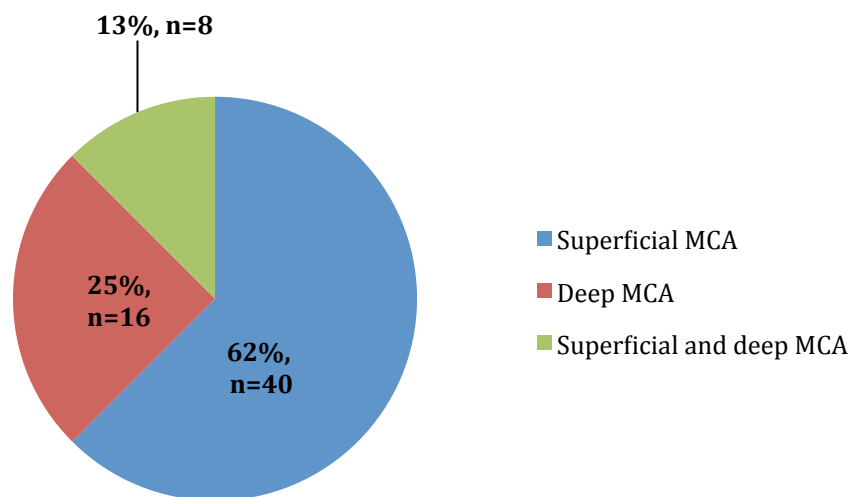


**Figure 1.** Preoperative MRI (T2\*-weighted sequence) showing a recent hemorrhagic conversion (8 mm) of a superficial right territory brain infarction.

For each patient, the topographic pattern of the cerebral ischemic lesion was analyzed. Sixteen watershed strokes were noted with a similar distribution between the both groups. Among these 16 patients, we found combined border-zone and territorial (in the middle cerebral artery (MCA) territory) stroke caused by multiple emboli in 9 patients. Among territorial strokes, we noticed a high proportion of superficial strokes (**Figure 2**). Systematic carotid duplex ultrasound imaging associated with CT angiography (or MRA in case of renal impairment) was performed to evaluate the internal carotid stenosis. Results are listed in **Table II**. All patients received medical therapy (antiplatelet and statin) before surgery. Ten eligible patients (14.1%) received thrombolytic therapy, all belonging to Group B (0% vs 19.2%;  $p = 0.04$ ).



**Figure 2a**



**Figure 2b**

**Figure 2.** Topographic pattern of stroke in the whole cohort (Figure 2a) and in the specific middle cerebral artery (MCA) territory (Figure 2b).



**Table II.** Brain imaging and results of carotid duplex ultrasound imaging.

<i>Variables<sup>a</sup></i>	<i>Total n = 71</i>	<i>Group A n = 19</i>	<i>Group B n = 52</i>	<i>p</i>
Brain imaging				
CT scan	15 (21.1)	2 (10.5)	13 (25)	0.32
MRI	56 (78.9)	17 (89.5)	39 (75)	0.32
Carotid duplex ultrasound imaging				
Significant ICA stenosis > 60% <sup>b</sup>	65 (91.5)	18 (94.7)	47 (90.4)	0.99
Residual ICA stenosis post-thrombolysis	1 (1.4)	0	1 (1.9)	0.99
Stenosis on single ICA	2 (2.8)	0	2 (3.8)	0.99
Nearly occlusive ICA stenosis	5 (7)	1 (5.3)	4 (7.7)	0.99
Contralateral stenosis on single ICA	1 (1.4)	0	1 (1.9)	0.99
ICA stenosis 50% (ulcerated plaque) <sup>b</sup>	5 (7)	1 (5.3)	4 (7.7)	0.99
Grade of ICA stenosis (%) <sup>b</sup>	75 [70 ; 80]	80 [70 ; 85]	72.5 [70 ; 80]	0.08

ICA, Internal Carotid Artery.

<sup>a</sup>Categoric data are shown as number (%) and continuous data as median [Q1 ; Q3]. <sup>b</sup>According to the NASCET criteria.

**Revascularization.** The mean interval from initial examination to surgery was 9.5 days (range, 3-14 days) in Group A and 42 days (range, 15-92 days) in Group B. All carotid revascularizations were done under general anesthesia. On the basis of residual pressure measurement and an evaluation of reflux in the ICA, 5 patients in Group A and 7 patients in Group B required shunting, without significant difference (26.4% vs 13.5%;  $p = 0.20$ ). The type of surgery used was similar in both groups, and the median duration of surgery was 112 minutes (IQR, 100-135 minutes). Carotid duplex imaging was systematically performed by the operator at the end of the revascularization. The operative results are summarized in **Table III**.

**Outcomes.** At one month, no death, no recurrent stroke or TIA and no cardiac complication had occurred in Group A with a 100% complete follow-up. In Group B, with a 98.1% follow-up (1 lost to follow-up), 2 patients had a postoperative stroke (**Table III**). The combined morbidity/mortality rate for both groups was 2.8%. The

combined morbidity/mortality rate for the Group B was 3.8%. At 3 months, with a 96.4% follow-up, all patients had favorable functional outcome. Follow-up carotid duplex imaging at 3 months showed 2 recurrent stenoses in patients who underwent bypass venous grafting.

**Table III.** Operative details and outcomes.

<i>Variables<sup>a</sup></i>	<i>Group A n = 19</i>	<i>Group B n = 52</i>	<i>p</i>
<b>Surgery</b>			
Timing. Onset - surgery, days	9.5 [3-14]	42 [15-92]	-
General anesthesia	19 (100)	52 (100)	-
<b>Type of surgery</b>			
Endarterectomy and direct closure	1 (5.3)	2 (3.8)	0.79
Endarterectomy and reversal	6 (31.6)	14 (26.9)	0.70
Endarterectomy + patch angioplasty <sup>b</sup>	6 (31.6)	9 (17.3)	0.19
Bypass venous grafting	5 (26.3)	25 (48.1)	0.10
Bypass prothetic grafting <sup>b</sup>	1 (5.3)	2 (3.8)	0.79
Shunting	5 (26.3)	7 (13.5)	0.20
Duration of surgery, minutes	110 [75-180]	120 [64-168]	0.02
Postoperative hypertension, >16mmHg	15 (78)	43 (82.7)	0.40
<b>30-day clinical outcomes</b>			
Stroke	0	2 (3.8)	0.39
Mortality	0	0	-
Cardiac event	0	0	-
<b>90-day duplex ultrasound imaging outcomes</b>			
Normal exam	17 (100)	48 (96)	0.40
Carotid stenosis	0	2 (4)	0.40
Lost to follow-up	2 (10.5)	2 (3.8)	-

<sup>a</sup>Categorical data are shown as number (%) and continuous data as mean [range]. <sup>b</sup>Polytetrafluoroethylene was used.

The two neurologic complications were acute postoperative strokes in the first 48 hours after surgery. The first was a 80-year-old man (ASA III) who had presented with left hemiplegia with an NIHSS score of 10. Initial brain imaging had shown a right superficial territorial stroke and he had undergone thrombolysis. Surgery had been performed 56 days after symptom onset and consisted of an endarterectomy with patch

angioplasty without shunting. The patient had presented postoperative hypertension (> 20mmHg) and suffered a new stroke in the recovery room. Control brain imaging showed a hematoma in the deep right MCA territory. The second patient was a 65-year-old man (ASA III) who had consulted for left hemiplegia with an NIHSS score of 7. Initial brain imaging had shown right deep territorial stroke. The 70% ICA stenosis had been operated 28 days after symptom onset with bypass venous grafting. Postoperative follow-up had been complicated by hypertension and a new stroke one day after surgery. A right occipital hematoma was found on control brain images.

Among the 12 patients who underwent shunting, 33.3% had a former history of stroke or TIA (vs 15.3% in the rest of the cohort). Their median grade of ICA stenosis was more severe (80% [IQR, 72.5-90%] vs 75% [IQR, 70-80%] ;  $p = 0.10$ ) and more near occlusive (>95%) ICA stenoses were revascularized (25% vs 3.4%;  $p = 0.03$ ). More watershed strokes were found in these patients (58.3% vs 15.3% ;  $p = 0.004$ ). None of these patients received thrombolysis and no postoperative complication occurred.

Among the ten patients who received thrombolysis, all had systemic hypertension. At admission, their neurologic status was more severe; the mean NIHSS score was 12 (range, 2-27) ( $p < 0.0001$ ) and all patients were classified as ASA III (100% vs 65.6% ;  $p = 0.03$ ). No patient underwent early surgery and the mean interval from initial examination to surgery was 46 days (range, 16-92 days).

## Discussion

This study is the result of a retrospective analysis of data from prospectively identified patients who underwent CEA for symptomatic carotid stenosis responsible of brain infarcts in our hospital from 2010 to 2014. Performing CEA in an urgent setting after a neurologic deficit requires strong collaboration between the vascular surgeons and neurologists that is nowadays possible thanks to stroke units. During the preoperative consultation, the timing of surgery is one of the most important issues.

For patients who require CEA after brain infarct, the key question is the extent to which the absolute benefits and risks of surgery are increased by early operation. In fact, the aim of early surgery is to restore blood flow to the ischemic penumbra, which improves neurologic symptoms, and to reduce the risk of carotid occlusion and recurrent stroke. However, the major risk of the ischemic lesion developing into a hemorrhagic stroke. Nevertheless, a recent literature review by Naylor et al<sup>16</sup> of 30-day outcomes and conversion rates from ischemic stroke to hemorrhagic stroke after early CEA, concluded that the rate of symptomatic intracranial hemorrhage was reassuring, from 0% to 2%.

The timing of surgery for patients who have suffered a TIA due to internal carotid stenosis is codified and is conventionally performed precociously.<sup>5-8</sup> For this reason, we decided to exclude from our study all patients who consulted for TIA, in order to focus on stroke outcomes. Results of urgent CEA depend on the operating team and the severity of the initial stroke, and this surgery is considered to be high risk. Nevertheless, several small monocentric studies have reported good results, including in patients with major strokes in the acute phase.<sup>15,17,18</sup> Lesèche et al described no death and no postoperative stroke in 27 patients who underwent CEA in the acute phase of stroke in evolution with a median delay of 6 days from symptom onset to surgery.<sup>13</sup> The results

of these studies tend to consider a prompt surgical approach. The aim of our study was to analyze our 30-day outcomes after early CEA compared to delayed CEA, and to evaluate the quality of our selection criteria.

In our study population, the results are satisfying with an overall combined morbidity/mortality rate of 2.8%. The lack of postoperative complication in Group A confirms the good selection of patients who underwent early CEA. These results can be explained by :

- Close cooperation between vascular surgeons, neurologists and neuroradiologists.
- Rapid diagnosis and easy access to brain imaging (80.3% of patients had a brain MRI that allows a more accurate analysis compared to brain CT scan).
- Optimal preoperative medical management.
- Standardized surgery performed by trained surgeons. In order to minimize perioperative risks, we implement: low mobilization of the ICA and the carotid bifurcation before clamping to prevent embolization, long arteriotomie with fixation of the stop of atheromatous plaque, and closure with patch angioplasty.
- Using systematic residual pressure measurement and/or brain monitoring, and duplex ultrasound imaging by the operator at the end of the surgery.

Selection criteria for early CEA follow local guidelines which are based on the experience of the surgical and neurologic teams. In fact, several conditions are necessary in order for us to recommend early CEA. The first condition is clinical improvement. Early CEA is proposed only if patients show signs of neurologic

improvement during the workup. When at admission the patient has a NIHSS score > 8, we are usually more cautious and don't hesitate to delay surgery. Early surgery is not performed if the patient suffers from a major disabling stroke. For patients with advanced age (> 85 years), the surgical indication depends of medical history, clinical condition and neurological improvement. We don't propose early surgery to patients who had undergone thrombolysis. On the other hand, decision depends on brain imaging. Hemorrhagic transformation, major ischemic infarct of 3cm or more, or brain edema are contradictions for early CEA. In those cases, we repeat brain imaging and regularly revalue the timing of surgery.

Our study has several strengths. First, the data collection was detailed and included more than 60 clinical, radiologic, anesthesia and surgical management variables. Second, all patients had a standardized preoperative and operative management, with prescheduled follow-up consultations at 30-days and 90-days and duplex ultrasound imaging to 90-days. Only one patient was lost to follow-up in the 30-day perioperative period. Lastly, the exclusion of patients with TIA reduced the interpretation biases towards good results of early CEA, which could have been increased by the usually excellent outcomes in these patients. However, this selection decreased the number of patients in both groups and the power of the study.

We recognize several limitations to our study. First, it was a retrospective study. This allowed a more thorough data collection and when the NIHSS score was missing, a recalculation was possible. In fact, the determination of the NIHSS score is partly subjective. Nonetheless, the neurologic examinations of patients secondarily addressed to our department were highly detailed enabling us to avoid major bias when recalculation was needed, as in 17 patients. Second, the Group A was rather small due to

a delay in the management of patients who were transferred secondarily to the university hospital, and a more cautious approach during the first 2 years of the study when the surgical team preferred to wait four weeks before operating. Among the 17 patients who initially consulted in small regional hospitals, only 3 patients (23.6%) had surgery in the two first weeks, and the others 14 patients were not more severe (mean NIHSS score 4 [range, 0-13]).

We compared our series of patients with other series reported recently in the literature (**Table IV**). The main observation is that many authors don't differentiate between TIA and stroke when considering the outcomes of early CEA, but present the results of the whole cohort of symptomatic patients. This lack of differentiation between the initial neurologic events complicates the interpretation and comparability of results between series. In contrast, others take into account the severity of the initial event and their results must be interpreted with respect to the different risk groups. For example, for Barbetta et al, the 30-day outcomes of early CEA in 90 patients were considered as satisfactory despite 4 deaths and 6 postoperative strokes; half of the complications occurring in 11 patients with severe stroke in evolution.<sup>15</sup>

**Table IV.** Comparison of surgical series.

<i>First author</i>	<i>Clinical presentation</i>				<i>Outcomes</i>		
	<i>U-CEA (n)</i>	<i>TIA (%)</i>	<i>Stroke (%)</i>	<i>Median delay (day)</i>	<i>Death (%)</i>	<i>MI (%)</i>	<i>Stroke (%)</i>
Barbetta (2014) <sup>15</sup>	90	27 (30)	63 (70)	2 (1-5)	4 (4.4)	/	6 (6.6)
Paty (2014) <sup>19</sup>	369	/	/	3.65	0	11 (3)	20 (5.4)
Tsivgoulis (2014) <sup>18</sup>	165	48 (30)	117 (70)	7 (1-14)	1 (0.6)	1 (0.6)	8 (4.8)
Chisci (2014) <sup>20</sup>	100	/	/	0-14	0	0	3 (3)
Faggioli (2013) <sup>21</sup>	60	38 (63.3)	22 (36.7)	0-14	1 (1.6)	0	4 (6.6)
Leseche (2012) <sup>13</sup>	27	0	27 (100)	6 (1-14)	0	1 (3.7)	0
Capoccia (2012) <sup>14</sup>	48	22 (45.8)	26 (54.2)	1	1 (2.1)	0	1 (2.1)
Ferrero (2010) <sup>22</sup>	131	70 (53.4)	61 (46.6)	0-14	1 (0.8)	/	5 (3.8)
Sbarigia (2006) <sup>23</sup>	96	38 (40)	58 (60)	1.5 (1-12)	2 (2.1)	1 (1)	5 (5.2)
Rockman (2006) <sup>24</sup>	182	0	182 (100)	0-30	4 (2.2)	2 (1.1)	17 (9.4)

*MI*, Myocardial infarction

In many series, results suggest that early CEA after brain infarct is safe. Our results are in the line with the literature. The lack of complications in Group A is explained by a good selection of patients. However, Lesèche et al reported excellent outcomes of early CEA performed in the acute phase of stroke in evolution,<sup>13</sup> a population with a higher risk profile that was excluded from Group A in our study. This could also explain our good results for this group. Several selection criteria (mainly radiological) are frequently proposed in the literature, however the subjectivity and the variability of the clinical recovery between patients after stroke prevents the proposal of an operability scale. The decision and the timing of surgery remain at the discretion and the expertise of the surgical team.



In our series, all patients who underwent thrombolysis were operated late with a mean time of 46 days. Guidelines recommend delaying surgery as much as possible after thrombolysis to decrease the risk of hemorrhage. Yet, with the increasing number of stroke units, the question of the rapid revascularization of residual ICA stenosis after thrombolysis has surfaced. Recent studies reported reassuring results but the series were small.<sup>25-28</sup> Among the two complications in our study, one was a postoperative stroke after thrombolysis and delayed CEA. We believe early CEA after thrombolysis should be considered; but larger series of patients are required to confirm the safety of this procedure.

A recent series from Nice, France, described more frequent postoperative complications among patients who underwent early CEA after a watershed infarct.<sup>29</sup> These data contrast with ours because we observed no complication in such patients, but our population was smaller with only 16 patients, including 6 who were treated early.

## **Conclusion**

Our results confirm that early CEA after acute ischemic stroke is safe but a strict clinical and radiological selection of patients is essential to prevent early neurological complications. As a result of the variability in the clinical improvement of patients after stroke, the experience of the surgical and neurological teams is crucial when deciding on the timing of CEA. The current trend is to perform early CEA in the acute phase of stroke. Larger series of patients are required to confirm the safety of this management strategy among some risk groups such as patients with stroke in evolution, patients who have watershed infarction or have undergone thrombolysis.

## Bibliography

1. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the MRC European Carotid Surgery Trial (ECST). *Lancet*. 9 mai 1998;351(9113):1379-87.
2. Barnett HJM, Taylor DW, Eliasziw M, Fox AJ, Ferguson GG, Haynes RB, et al. Benefit of Carotid Endarterectomy in Patients with Symptomatic Moderate or Severe Stenosis. *New England Journal of Medicine*. 12 nov 1998;339(20):1415-25.
3. Mayberg MR, Wilson SE, Yatsu F, Weiss DG, Messina L, Hershey LA, et al. Carotid endarterectomy and prevention of cerebral ischemia in symptomatic carotid stenosis. Veterans Affairs Cooperative Studies Program 309 Trialist Group. *JAMA*. 18 déc 1991;266(23):3289-94.
4. Rothwell PM, Eliasziw M, Gutnikov SA, Fox AJ, Taylor DW, Mayberg MR, et al. Analysis of pooled data from the randomised controlled trials of endarterectomy for symptomatic carotid stenosis. *Lancet*. 11 janv 2003;361(9352):107-16.
5. Bond R, Rerkasem K, Rothwell PM. Systematic review of the risks of carotid endarterectomy in relation to the clinical indication for and timing of surgery. *Stroke*. sept 2003;34(9):2290-301.
6. Rothwell PM, Eliasziw M, Gutnikov SA, Warlow CP, Barnett HJM. Sex difference in the effect of time from symptoms to surgery on benefit from carotid endarterectomy for transient ischemic attack and nondisabling stroke. *Stroke*. déc 2004;35(12):2855-61.
7. Rothwell PM, Eliasziw M, Gutnikov SA, Warlow CP, Barnett HJM, Carotid Endarterectomy Trialists Collaboration. Endarterectomy for symptomatic carotid stenosis in relation to clinical subgroups and timing of surgery. *Lancet*. 20 mars 2004;363(9413):915-24.
8. Ballotta E, Meneghetti G, Da Giau G, Manara R, Saladini M, Baracchini C. Carotid endarterectomy within 2 weeks of minor ischemic stroke: a prospective study. *J Vasc Surg*. sept 2008;48(3):595-600.
9. Salem MK, Sayers RD, Bown MJ, Eveson DJ, Robinson TG, Naylor AR. Rapid Access Carotid Endarterectomy can be Performed in the Hyperacute Period without a Significant Increase in Procedural Risks. *European Journal of Vascular and Endovascular Surgery*. 1 févr 2011;41(2):222-8.

10. Department of Health. National Stroke Strategy. *www.dh.gov.uk/stroke* 2007. Accessed April 28, 2009.
11. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med.* 15 août 1991;325(7):445-53.
12. MRC European Carotid Surgery Trial: interim results for symptomatic patients with severe (70-99%) or with mild (0-29%) carotid stenosis. European Carotid Surgery Trialists' Collaborative Group. *Lancet.* 25 mai 1991;337(8752):1235-43.
13. Leseche G, Alsac J-M, Houbbalah R, Castier Y, Fady F, Mazighi M, et al. Carotid endarterectomy in the acute phase of stroke-in-evolution is safe and effective in selected patients. *Journal of Vascular Surgery.* 1 mars 2012;55(3):701-7.
14. Capoccia L, Sbarigia E, Speziale F, Toni D, Biello A, Montelione N, et al. The need for emergency surgical treatment in carotid-related stroke in evolution and crescendo transient ischemic attack. *Journal of Vascular Surgery.* 1 juin 2012;55(6):1611-7.
15. Barbetta I, Carmo M, Mercandalli G, Lattuada P, Mazzaccaro D, Settembrini AM, et al. Outcomes of urgent carotid endarterectomy for stable and unstable acute neurologic deficits. *J Vasc Surg.* févr 2014;59(2):440-6.
16. Naylor AR. Delay May Reduce Procedural Risk, But at What Price to the Patient? *European Journal of Vascular and Endovascular Surgery.* 1 avr 2008;35(4):383-91.
17. Gertler JP, Blankensteijn JD, Brewster DC, Moncure AC, Cambria RP, LaMuraglia GM, et al. Carotid endarterectomy for unstable and compelling neurologic conditions: do results justify an aggressive approach? *J Vasc Surg.* janv 1994;19(1):32-40; discussion 40-2.
18. Tsivgoulis G, Krogias C, Georgiadis GS, Mikulik R, Safouris A, Meves SH, et al. Safety of early endarterectomy in patients with symptomatic carotid artery stenosis: an international multicenter study. *Eur J Neurol.* oct 2014;21(10):1251-7, e75-6.
19. Paty PSK, Bernardini GL, Mehta M, Feustel PJ, Desai K, Roddy SP, et al. Standardized protocols enable stroke recognition and early treatment of carotid stenosis. *J Vasc Surg.* juill 2014;60(1):85-91.
20. Chisci E, Pigozzi C, Troisi N, Tramacere L, Zaccara G, Cincotta M, et al. Thirty-Day Neurologic Improvement Associated with Early versus Delayed Carotid Endarterectomy in Symptomatic Patients. *Ann Vasc Surg.* avr 2015;29(3):435-42.

21. Faggioli G, Pini R, Mauro R, Gargiulo M, Freyrie A, Stella A. Perioperative outcome of carotid endarterectomy according to type and timing of neurologic symptoms and computed tomography findings. *Ann Vasc Surg.* oct 2013;27(7):874-82.
22. Ferrero E, Ferri M, Viazzo A, Labate C, Berardi G, Pecchio A, et al. A Retrospective Study on Early Carotid Endarterectomy within 48 Hours after Transient Ischemic Attack and Stroke in Evolution. *Annals of Vascular Surgery.* 1 janv 2014;28(1):227-38.
23. Sbarigia E, Toni D, Speziale F, Acconcia MC, Fiorani P. Early Carotid Endarterectomy after Ischemic Stroke: The Results of a Prospective Multicenter Italian Study. *European Journal of Vascular and Endovascular Surgery.* 1 sept 2006;32(3):229-35.
24. Rockman CB, Maldonado TS, Jacobowitz GR, Cayne NS, Gagne PJ, Riles TS. Early carotid endarterectomy in symptomatic patients is associated with poorer perioperative outcomes. *Journal of Vascular Surgery.* 1 sept 2006;44(3):480-7.
25. McPherson CM, Woo D, Cohen PL, Pancioli AM, Kissela BM, Carrozzella JA, et al. Early Carotid Endarterectomy for Critical Carotid Artery Stenosis After Thrombolysis Therapy in Acute Ischemic Stroke in the Middle Cerebral Artery. *Stroke.* 9 janv 2001;32(9):2075-80.
26. Bartoli MA, Squarcioni C, Nicoli F, Magnan P-E, Malikov S, Berger L, et al. Early carotid endarterectomy after intravenous thrombolysis for acute ischaemic stroke. *Eur J Vasc Endovasc Surg.* mai 2009;37(5):512-8.
27. Crozier JEM, Reid J, Welch GH, Muir KW, Stuart WP. Early carotid endarterectomy following thrombolysis in the hyperacute treatment of stroke. *Br J Surg.* févr 2011;98(2):235-8.
28. Rathenborg LK, Venermo M, Troëng T, Jensen LP, Vikatmaa P, Wahlgren C, et al. Editor's choice - Safety of carotid endarterectomy after intravenous thrombolysis for acute ischaemic stroke: a case-controlled multicentre registry study. *Eur J Vasc Endovasc Surg.* déc 2014;48(6):620-5.
29. Jean-Baptiste E, Perini P, Suissa L, Lachaud S, Declémy S, Mahagne MH, et al. Prognostic value of preoperative border-zone (watershed) infarcts on the early postoperative outcomes of carotid endarterectomy after acute ischemic stroke. *Eur J Vasc Endovasc Surg.* mars 2013;45(3):210-7.

## **List of abbreviations**

**ASA** : American Society of Anesthesiologists

**BMI** : Body Mass Index

**CEA** : Carotid Endarterectomy

**CT-scan** : Computed Tomography-scan

**ICA** : Internal Carotid Artery

**IQR** : Interquartile Range

**MCA** : Middle Cerebral Artery

**MRA** : Magnetic Resonance Angiography

**MRI** : Magnetic Resonance Imaging

**NASCET** : North American Symptomatic Carotid Endarterectomy Trial

**NIHSS** : National Institute of Health Stroke Scale

**TIA** : Transient Ischemic Attack

## ANNEX : NIHSS score

<b>1A Level of consciousness</b> 0— alert 1— drowsy 2— obtunded 3— coma/ unresponsive	<b>3 Visual fields</b> 0— no visual field defect 1— partial hemianopia 2— complete hemianopia 3— bilateral hemianopia	<b>7 Limb ataxia</b> 0— no ataxia 1— ataxia in one limb 2— ataxia in two limbs <b>8 Sensory</b> 0— no sensory loss 1— mild sensory loss 2— severe sensory loss
<b>1B Orientation questions (two)</b> 0— answers both correctly 1— answers one correctly 2— answers neither correctly	<b>4 Facial movements</b> 0— normal 1— minor facial weakness 2— partial facial weakness 3— complete unilateral palsy	<b>9 Language</b> 0— normal 1— mild aphasia 2— severe aphasia 3— mute or global aphasia
<b>1C Response to commands (two)</b> 0— performs both tasks correctly 1— performs one task correctly 2— performs neither	<b>5 Motor function (arm)</b> 0— no drift 1— drift before 10 seconds 2— falls before 10 seconds 3— no effort against gravity 4— no movement a- left, b- right	<b>10 Articulation</b> 0— normal 1— mild dysarthria 2— severe dysarthria
<b>2 Gaze</b> 0— normal horizontal movements 1— partial gaze palsy 2— complete gaze palsy	<b>6 Motor function (leg)</b> 0— no drift 1— drift before 5 seconds 2— falls before 5 seconds 3— no effort against gravity 4— no movement a- left, b- right	<b>11 Extinction or inattention</b> 0— absent 1— mild (loss of 1 sensory modality) 2— severe (loss of 2 sensory modalities)

THESE SOUTENUE PAR : **Mr PEROU Sébastien**

TITRE :

**Results of early versus delayed carotid surgery after acute ischemic stroke**

CONCLUSION :

**Objective:** The aim of this study was to evaluate the 30-day outcomes of patients with an internal carotid artery (ICA) stenosis responsible for an acute brain infarction who underwent early ( $\leq 14$  days) or delayed (15 days to 3 months) carotid endarterectomy CEA.

**Methods:** From July 2010 to June 2014, we studied all patients with a recent cerebral infarction who underwent CEA within 3 months after the onset of symptoms. This was a continuous, monocentric, and retrospective series. The preoperative management was the same for each patient: a clinical assessment was done by a neurologist using the National Institute of Health Stroke Scale (NIHSS) score, systematic brain imaging (CT or MRI) was performed to eliminate hemorrhagic infarction and duplex ultrasound imaging combined with CT or MR angiography, were used for diagnosis of ICA stenosis ( $> 60\%$ ). Optimal medical treatment was delivered as soon as diagnosis was confirmed, and eligible patients received thrombolysis. Two groups were identified: Group A with patients who underwent CEA in the first fourteen days after symptom onset; and Group B with patients who underwent CEA from the fifteenth day to the third month after symptom onset. Death, stroke and major cardiac events were analyzed.

**Results:** Seventy-one patients with ICA stenosis responsible for an acute brain infarction underwent CEA (73.2% men, 26.8% women, with a median age of 71 [IQR, 65-78 years old]). Nineteen patients underwent early carotid revascularization (Group A) and 52 underwent delayed carotid revascularization (Group B). In Group A, the mean NIHSS score at admission was 3 (range, 0-7) and the mean interval from initial



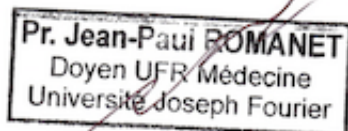
examination to surgery was 9.5 days (range, 3-14 days). Brain infarction was confirmed in 89.5% by brain MRI and the median grade of ICA stenosis was 80% (IQR, 70-85%). In Group B, the mean NIHSS score at admission was more severe (5 [range, 0-27];  $P = 0.04$ ) and the mean time from symptom onset to surgery was 42 days (range, 15-92 days). Brain MRI was performed in 75% and the median grade of ICA stenosis was 72.5% (IQR, 70-80%). Ten patients in Group B received thrombolysis. All CEA were done under general anesthesia. Selective shunting was used in 5 patients in Group A and in 7 patients in Group B (26.3% vs 13.5%;  $p = 0.20$ ). After one month, and with a 98.6% follow-up (1 lost to follow-up), no postoperative complication occurred in Group A and 2 patients in Group B had a post-operative stroke (3.8%).

**Conclusion:** This retrospective study confirms the satisfactory outcomes of early CEA after acute brain infarct. A strict clinical and radiological selection of patients prevents early neurological complications.

VU ET PERMIS D'IMPRIMER

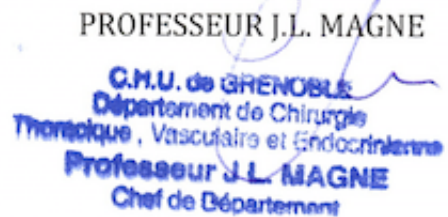
Grenoble, le 02/04/2015

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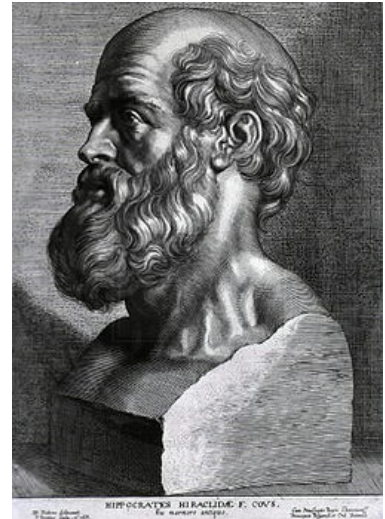


J.P. ROMANET

LE PRESIDENT DE LA THESE



# SERMENT D'HIPPOCRATE



*En présence des Maîtres de cette Faculté, de mes chers condisciples et devant l'effigie d'HIPPOCRATE,*

*Je promets et je jure d'être fidèle aux lois de l'honneur et de la probité dans l'exercice de la Médecine.*

*Je donnerai mes soins gratuitement à l'indigent et n'exigerai jamais un salaire au-dessus de mon travail. Je ne participerai à aucun partage clandestin d'honoraires.*

*Admis dans l'intimité des maisons, mes yeux n'y verront pas ce qui s'y passe ; ma langue taira les secrets qui me seront confiés et mon état ne servira pas à corrompre les mœurs, ni à favoriser le crime.*

*Je ne permettrai pas que des considérations de religion, de nation, de race, de parti ou de classe sociale viennent s'interposer entre mon devoir et mon patient.*

*Je garderai le respect absolu de la vie humaine.*

*Même sous la menace, je n'admettrai pas de faire usage de mes connaissances médicales contre les lois de l'humanité.*

*Respectueux et reconnaissant envers mes Maîtres, je rendrai à leurs enfants l'instruction que j'ai reçue de leurs pères.*

*Que les hommes m'accordent leur estime si je suis fidèle à mes promesses.*

*Que je sois couvert d'opprobre et méprisé de mes confrères si j'y manque.*

## Résumé

**Titre :** Résultats du traitement chirurgical précoce et tardif des sténoses carotidiennes symptomatiques responsables d'infarctus cérébral.

**Objectif :** Evaluer les résultats des patients opérés d'une sténose carotidienne symptomatique responsable d'un infarctus cérébral, après une revascularisation précoce (< 14 jours) ou tardive (de 14 jours à 3 mois).

**Méthodes :** Etude rétrospective monocentrique incluant tous les patients ayant bénéficié d'une chirurgie carotidienne dans les 3 mois après un infarctus cérébral de Juillet 2010 à Juin 2014. Le Groupe A concernait les patients qui ont bénéficié d'une revascularisation dans les 14 premiers jours après le début des symptômes et le Groupe B les patients qui ont été opérés entre 15 jours et 3 mois après le début des symptômes. La mortalité, le taux d'infarctus cérébral et les complications cardiaques post-opératoires ont été analysés.

**Résultats :** Soixante et onze patients ont été opérés d'une sténose carotidienne symptomatique avec un infarctus cérébral (73.2% d'hommes, 26.8% de femmes, âge médian de 71 ans [65 ; 78]). Dix-neuf patients ont été revascularisés précocement (Groupe A) avec un délai moyen de prise en charge chirurgicale de 9.5 jours [3-14] et 52 ont été opérés tardivement (Groupe B) avec un délai moyen de prise en charge chirurgicale de 42 jours [15-92] dans le Groupe B. Dix patients du groupe B ont bénéficié d'une thrombolyse. Toutes les revascularisations ont été réalisées sous anesthésie générale. Un shunt sélectif a été utilisé chez 5 patients du groupe A et chez 7 patients du groupe B (26.3% vs 13.5% ;  $p = 0.20$ ). Le suivi à un mois de 98.6% des patients (1 perdu de vue), n'a montré dans le groupe A aucune complication post-opératoire ; dans le groupe B on observait 2 hématomes cérébraux (3.8%) responsables d'AVC.

**Conclusion :** Cette étude rétrospective confirme le résultat satisfaisant des revascularisations carotidiennes précoces après infarctus cérébral. Une sélection clinique et radiologique rigoureuse des patients permet d'éviter les complications neurologiques précoces.

**Mots clefs :** sténose carotidienne, symptomatique, revascularisation, précoce, résultats.