ANESTHESIOLOGY

General Anesthesia *versus* Sedation, Both with Hemodynamic Control, during Intraarterial Treatment for Stroke: The GASS Randomized Trial

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EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- Intraarterial endovascular thrombectomy is considered as a standard of care for patients with ischemic stroke caused by a large vessel occlusion in the anterior cerebral circulation
- The question whether periprocedural conscious sedation *versus* general anesthesia influences neurologic outcome in these patients is incompletely explored

What This Article Tells Us That Is New

- In this single-blind, randomized trial including patients with large vessel occlusion of the anterior cerebral circulation, standardized general anesthesia and standardized conscious sedation for endovascular therapy resulted in comparable modified Rankin scores when evaluated 3 months after intervention
- These observations suggest that the functional outcome 3 months after endovascular treatment for ischemic stroke is comparable for general anesthesia and sedation

ABSTRACT

Background: It is speculated that the anesthetic strategy during endovascular therapy for stroke may have an impact on the outcome of the patients. The authors hypothesized that conscious sedation is associated with a better functional outcome 3 months after endovascular therapy for the treatment of stroke compared with general anesthesia.

Methods: In this single-blind, randomized trial, patients received either a standardized general anesthesia or a standardized conscious sedation. Blood pressure control was also standardized in both groups. The primary outcome measure was a modified Rankin score less than or equal to 2 (0 = no symptoms; 5 = severe disability) assessed 3 months after treatment. The main secondary outcomes were complications, mortality, reperfusion results, and National Institutes of Health Stroke Scores at days 1 and 7.

Results: Of 351 randomized patients, 345 were included in the analysis. The primary outcome occurred in 129 of 341 (38%) of the patients: 63 (36%) in the conscious sedation group and 66 (40%) in the general anesthesia group (relative risk, 0.91 [95% CI, 0.69 to 1.19]; $P = 0.474$). Patients in the general anesthesia group experienced more intraoperative hypo- or hypertensive episodes, while the cumulative duration was not different (mean ± SD, 36 ± 31 *vs.* 39 ± 25 min; $P = 0.079$). The time from onset and from arrival to puncture were longer in the general anesthesia group (mean difference, 19 min [*i.e.*, –00:19] [95% CI, –0:38 to 0] and mean difference, 9 min [95% CI, –0:18 to –0:01], respectively), while the time from onset to recanalization was similar in both groups. Recanalization was more often successful in the general anesthesia group (144 of 169 [85%] *vs.* 131 of 174 [75%]; $P = 0.021$). The incidence of symptomatic intracranial hemorrhage was similar in both groups.

Conclusions: The functional outcomes 3 months after endovascular treatment for stroke were similar with general anesthesia and sedation. Our results, therefore, suggest that clinicians can use either approach.

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Endovascular therapy in addition to the medical treatment is now the standard of care for select patients who had a stroke caused by a large vessel occlusion in the anterior circulation.[1] The two main factors associated with a good outcome are time, namely the rapidity of the treatment,[2] and hemodynamic conditions.[3,4]

In this context, the best anesthetic strategy during the endovascular treatment is still a matter of debate. While allowing for immobility, cerebral protection, and airway control, general anesthesia can delay the endovascular treatment and, if not controlled, can be associated with hemodynamic instability. On the other hand, conscious sedation is faster and allows for neurologic assessment during a

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procedure, but thrombectomy can be less safe for the neuroradiologist because of patient movement. More hemodynamic stability was reported in retrospective studies.[5–7] Studies published thus far report controversial results: conscious sedation is associated with better outcomes[8–10] in some studies; the two techniques have similar outcomes in other studies.[11–14] A meta-analysis including the first three randomized controlled trials on the subject recommended systematic study of the relationship that stroke and treatment-related variables have with outcomes after endovascular therapy.[15] The Diffusion and Perfusion Imaging Evaluation for Understanding Stroke Evolution (DEFUSE) study found that patients who underwent thrombectomy with conscious sedation had a higher likelihood of functional independence at 90 days and a lower National Institutes of Health (Bethesda, Maryland) Stroke Score at 24 h.[10] However, the choice between general anesthesia and conscious sedation was left to the discretion of the team, and the protocols were neither detailed nor standardized.[10] Indeed, previous studies did not focus on anesthetic protocol and intraoperative hemodynamic control.[16] Moreover, the difference between profound conscious sedation and light general anesthesia has not always been clearly identified.[11] A randomized trial including a protocolized aspect of hemodynamic control has been frequently recommended.[16]

To address this uncertainty, we conducted the General Anesthesia *versus* Sedation for Acute Stroke Treatment (GASS) trial to evaluate the hypothesis that conscious sedation would be associated with better clinical outcomes as measured by modified Rankin score 3 months after the procedure.

Materials and Methods

Study Design

This was an investigator-initiated, prospective, multicenter, parallel-group, single-blind, randomized, controlled, superiority trial conducted in four centers in France (Rennes Hospital [Rennes, France], Brest Hospital [Brest, France], Tours Hospital [Tours, France], and the Rothschild Foundation in Paris [Paris, France] [clinical trial registration No. NCT02822144; July 4, 2016; principal investigator, Helene Beloeil]). The rationale and design of the study have been reported previously.[17] The study was approved for all centers by a central ethics committee (Comité de Protection des Personnes Poitiers Ouest III, June 13, 2016; National Agency for Drug Safety: March 8, 2016, No. 160454A-31). Written informed consent was obtained from all participating patients or relatives either before inclusion in the study or after an emergency procedure for inclusion. (The patient was included and randomized before his/her or a relative's consent, and informed as soon as his/her condition allowed information and his/her consent was sought for the possible continuation of the research and/or the use of his/her data. If the patient died before consent was obtained or if, at the end of the trial [end of patient follow-up], the patient was still not able to understand the information and provide consent, the data collected in the study could be used if a relative gave consent or if the relative could not be reached after several attempts.) An independent data and safety monitoring board oversaw the study conduct and reviewed blinded safety data.

Patients

We studied patients older than 18 yr who had given written informed consent and who were admitted to a participating center for occlusion of a large vessel in the anterior cerebral circulation, admitted for endovascular therapy,[17] and affiliated with a social security system. Noninclusion criteria included patients who were already intubated and mechanically ventilated before inclusion in the study; had intracerebral hemorrhage associated with the ischemic stroke; were contraindicated for conscious sedation (*e.g.,* Glasgow coma scale less than 8; agitation preventing patient from staying still during the procedure; deglutition disorder) or succinylcholine (*e.g.,* hyperkalemia, body mass index greater than 35 kg/m^2); had known allergies to any of the drugs used for anesthesia or to any of their excipients, uncontrolled hypotension, or life-threatening comorbidity; could not walk; had a previous stroke; were pregnant or breastfeeding; were legally protected adults (*e.g.,* under judicial protection, guardianship, or supervision); or were persons deprived of their liberty).

Randomization and Interventions

Patients underwent randomization in a 1:1 ratio to undergo either general anesthesia or conscious sedation. Randomization was centralized and computer generated, and each patient was given a unique randomization number (patient code). It was a block-randomization stratified by center, the National Institutes of Health Stroke Scores of Health Stroke Score (less than or equal to 14 or greater than 14), and the administration (or not) of IV thrombolysis. Investigators proposed participation in the study to patients on arrival at the stroke center, obtained written informed consent (or proceeded to an emergency procedure), and randomized patients as close as possible to the endovascular therapy. Treatment assignments were concealed from patients, nonmedical research staff, the statistician, and the data and safety monitoring committee. Although staff members who collected data during surgery were aware of group assignments, outcome assessors were not aware of these assignments throughout the study.

Protocol

Previously published trial protocol[17] involved the standardization of anesthesia induction and maintenance. Patients in the general anesthesia group received etomidate (0.25 to 0.4 mg/kg) and then target-controlled infusion propofol

(maximum target, 4 μg/ml) and target-controlled infusion remifentanil (0.5 to 4 ng/ml) and succinylcholine (1 mg/kg). Muscle relaxant reinjection was authorized as needed. Patients in the conscious sedation group received target-controlled infusion remifentanil (maximum target, 2 ng/ml) and local anesthesia with lidocaine 10 mg/ml (maximum, 10 ml). Oxygen was administered only if oxygen saturation measured by pulse oximetry was less than or equal to 96%. Respiratory rate and capnography were monitored. Conversion from conscious sedation to general anesthesia was also standardized and allowed in the following situations: agitation or restlessness not allowing the endovascular treatment; vomiting not allowing the endovascular treatment; Glasgow coma scale less than 8; and/or deglutition disorders, severe hypoxemia with oxygen saturation measured by pulse oximetry at less than 96% with oxygen being delivered *via* high-concentration mask (maximum, 10 l/min), respiratory rate greater than 35/min, and/or clinical signs of respiratory exhaustion.

In both groups, intraoperative dose changes were left to the anesthesiologist in charge of the patient. The maintenance of blood pressure during the endovascular treatment was standardized. IV norepinephrine was administered in order to maintain blood pressure within the recommended range (*i.e.*, systolic blood pressure between 140 and 185 mmHg; diastolic blood pressure less than 110 mmHg). A decrease of more than 25% of the mean blood pressure was not tolerated. Postoperatively, blood pressure targets were defined as a systolic blood pressure less than 180 mmHg, diastolic blood pressure less than 110 mmHg, and mean arterial blood pressure greater than 65 mmHg. In case of a Thrombolysis in Cerebral Ischemia grade 2a or lower, the objective was a mean arterial blood pressure greater than 75 mmHg. Intraoperative blood pressure was continuously and noninvasively monitored with a cuff. The frequency of blood pressure measurements was not standardized postoperatively. In order to reach these blood pressure targets, norepinephrine was administered *via* a continuous infusion in a dedicated IV line and diluted at 250 μg/ml. The dose administered was adapted to blood pressure.

A systematic immediate post–endovascular treatment cone beam computed tomography scan was performed for all patients. Decisions about all other aspects of patient care were performed according to the expertise of the staff at each center and to routine clinical practice to minimize interference with the trial intervention.

Measurements

Primary Outcome. The primary outcome was the neurologic outcome assessed by modified Rankin score between 2 and 6 months after the endovascular treatment. Success was considered as a modified Rankin score of 2 or less. The modified Rankin score was assessed by trained research nurses blinded to the randomization group.

An additional exploratory analysis of the primary endpoint was performed to assess treatments effects according to baseline National Institutes of Health Stroke Score (less than or equal to 14 or greater than 14) and the administration or not of IV thrombolysis.

Secondary Outcomes. Secondary outcomes were time from stroke onset to groin puncture; time from arrival in the stroke center to groin puncture; technical failure of the endovascular treatment (defined as failure of arterial puncture or catheterization); reperfusion results evaluated by the neuroradiologist (good reperfusion corresponded to a modified treatment in cerebral ischemia scale score of 2b or 3); National Institutes of Health Stroke Scale score at day 1 (*i.e.*, day after the endovascular treatment) and day 7 (or the day the patient left the hospital if scheduled before day 7); complications during the procedure (dissection, rupture of the artery, thrombus in another territory); mortality rate 3 months after the endovascular treatment; number of hypo- or hypertensive events during the procedure and the first 24 h after the procedure (hypotension was defined as systolic blood pressure less than 140 mmHg or a decrease in the mean arterial blood pressure of 40% or more; hypertension was defined as systolic blood pressure greater than 185 mmHg or diastolic blood pressure greater than 110 mmHg); number of patients who received norepinephrine; and number of conversions from conscious sedation to general anesthesia.

Statistical Analysis

Sample size was calculated as a 30% rate of patients with a good prognosis (defined as modified Rankin score of 2 or less) after endovascular therapy under general anesthesia[12] and 45% after endovascular treatment under conscious sedation. Therefore, 166 patients per group were needed to have 80% power at a two-sided α level of 0.05. To allow for potential unevaluable patients, the number of patients to be enrolled was increased to 350 patients.

Statistical analysis was conducted on an intention-to-treat basis. A first overall descriptive analysis and analysis by group was performed. This consisted of separate estimates: numbers and percentages for qualitative variables, and means ± SD or medians and interquartile intervals for quantitative variables. The primary endpoint was compared between the two groups with the chi-square test. Two interim analyses after inclusion of one third and two thirds of patients and one final analysis were planned. Stopping rules were the α-spending function with the O'Brien–Fleming boundary. The cumulative values of α for each analysis were 0.00021 at first analysis; 0.01202 at second analysis; and 0.04626 at final analysis (nTerim, V.1.1; Statistical Solutions Ltd., Ireland). The trial would have been stopped early if the significance of the chi-square test was below these α values. For the analysis of the other endpoints, an independent sample *t* test or Mann–Whitney U test, if necessary, was used to compare continuous or discrete data, and a chi-square or Fisher

exact test, if necessary, was used to compare categorical data between two groups at inclusion. Except for the interim analyses, a *P* value less than 0.05 was considered as significant for all analyses. Planned subgroup analyses were performed on the primary endpoint according to the National Institutes of Health Stroke Scale (score less than or equal to 14 or greater than 14) and IV thrombolysis. Sensitivity analyses were performed on the primary endpoint according to the date of modified Rankin score collection (collection before 6 months; collection before 4 months). Missing values were imputed on neither primary endpoint (because the proportion of missing data was less than 2%) nor on secondary endpoints. After examination of the data, adjustment for confounding variables was not necessary. Analyses were performed using SAS software (V.9.4; USA).

Results

Patients

Of the 3,472 screened patients between September 2016 through June 2020 (408 at Brest Hospital; 920 at Rennes Hospital; 868 at Tours Hospital; 1,276 at Rothschild Foundation in Paris), 351 underwent randomization and 345 (conscious sedation, 177; general anesthesia, 174) were included in the analysis (fig. 1). Data on primary outcome were available for 176 patients in the conscious sedation group and 169 in the general anesthesia group.

The demographic, clinical, and stroke characteristics of the two groups are presented tables 1 and 2. They were similar except for two preoperative treatments. More patients were treated for hypertension (with conversion enzyme inhibitors) and with oral anticoagulants in the conscious sedation group compared with the general anesthesia group (table 1). Endovascular treatment was realized in 88% of patients in the conscious sedation group and 91% of patients in the general anesthesia group ($P = 0.353$). Two patients in the conscious sedation group and three in the general anesthesia group received a second endovascular treatment. Conscious sedation was converted into general anesthesia for eight patients (4%) for the following reasons: agitation (n = 4); vomiting (n = 1); Glasgow coma scale less than 8 (n = 1); hypoxemia (n = 1); or other (failure of catheter, respiratory arrest; n = 3).

Primary Outcome

A favorable neurologic outcome with a modified Rankin score of 2 or less at 3 months after treatment was seen in 129 (38%) of the 341 patients; 63 (36%) patients in the conscious sedation group and 66 (40%) in the general anesthesia group had favorable outcomes with no statistical differences (relative risk, 0.91 [95% CI, 0.69 to 1.19]; $P = 0.474$; fig. 2). Modified Rankin scores were evaluated between 2 and 6 months after treatment in 94% of patients in the conscious sedation group and 96% in the general anesthesia group ($P = 0.288$); modified Rankin scores were evaluated after 6 months in 6% of patients. Specifically, median time of assessment of the modified Rankin score was 111 days (interquartile range, 95 to 132) for both patients receiving conscious sedation and patients receiving general anesthesia (interquartile range, 92 to 130), with no statistical difference ($P = 0.755$).

Results were similar when adjusted to baseline National Institutes of Health Stroke Scale score (less than or equal to 14 [relative risk, 0.91 {95% CI, 0.64 to 1.31}; $P = 0.858$]) or administration of IV thrombolysis (relative risk, 0.91 [95% CI, 0.65 to 1.28]; $P = 0.942$).

Secondary Outcomes

Patients in the general anesthesia group experienced more intraoperative hypotension and hypertension episodes (table 3). They also received statistically significantly more vasoactive drugs. As shown in table 3, epinephrine was administered to some patients despite the protocol specifying that hypotension had to be treated with norepinephrine. The cumulative duration of hypotension was similar in both groups (table 3). The time from onset and from arrival to puncture were longer in the general anesthesia group (table 3). The time from onset to recanalization was similar in both groups (table 3). Recanalization (a modified Treatment in Cerebral Infarction score of 2b to 3) was more often successful in the general anesthesia group (table 3). Twenty-one patients in the conscious sedation group did not benefit from endovascular treatment: 13 (65%) experienced failure of the endovascular treatment; arterial occlusion was not found during angiography for 7 patients (35%); and the reason was not reported for 1 patient. Fifteen patients did not benefit from endovascular treatment in the general anesthesia group: 4 (27%) experienced failure of the endovascular treatment; and in 11 (73%) patients, the arterial occlusion was not found during angiography. The technical failure rate was low (17 of 345 [4.9%]), but significantly different: 13 of 176 (7.3%) in the conscious sedation group and 4 of 169 (2.3%) in the general anesthesia group ($P = 0.044$). The rate of symptomatic intracranial hemorrhage was similar in both groups. (table 3). Finally, results were similar within all four centers.

Discussion

In this multicenter, randomized trial, conscious sedation or general anesthesia during endovascular therapy for stroke resulted in a similar outcome when modified Rankin scores were evaluated at 3 months. There was a greater incidence of technical failure of endovascular therapy in the conscious sedation group, while recanalization was better in the general anesthesia group. Patients experienced more episodes of hyper- and hypotension in the general anesthesia group; however, the cumulative duration of hypotension was similar in both groups.

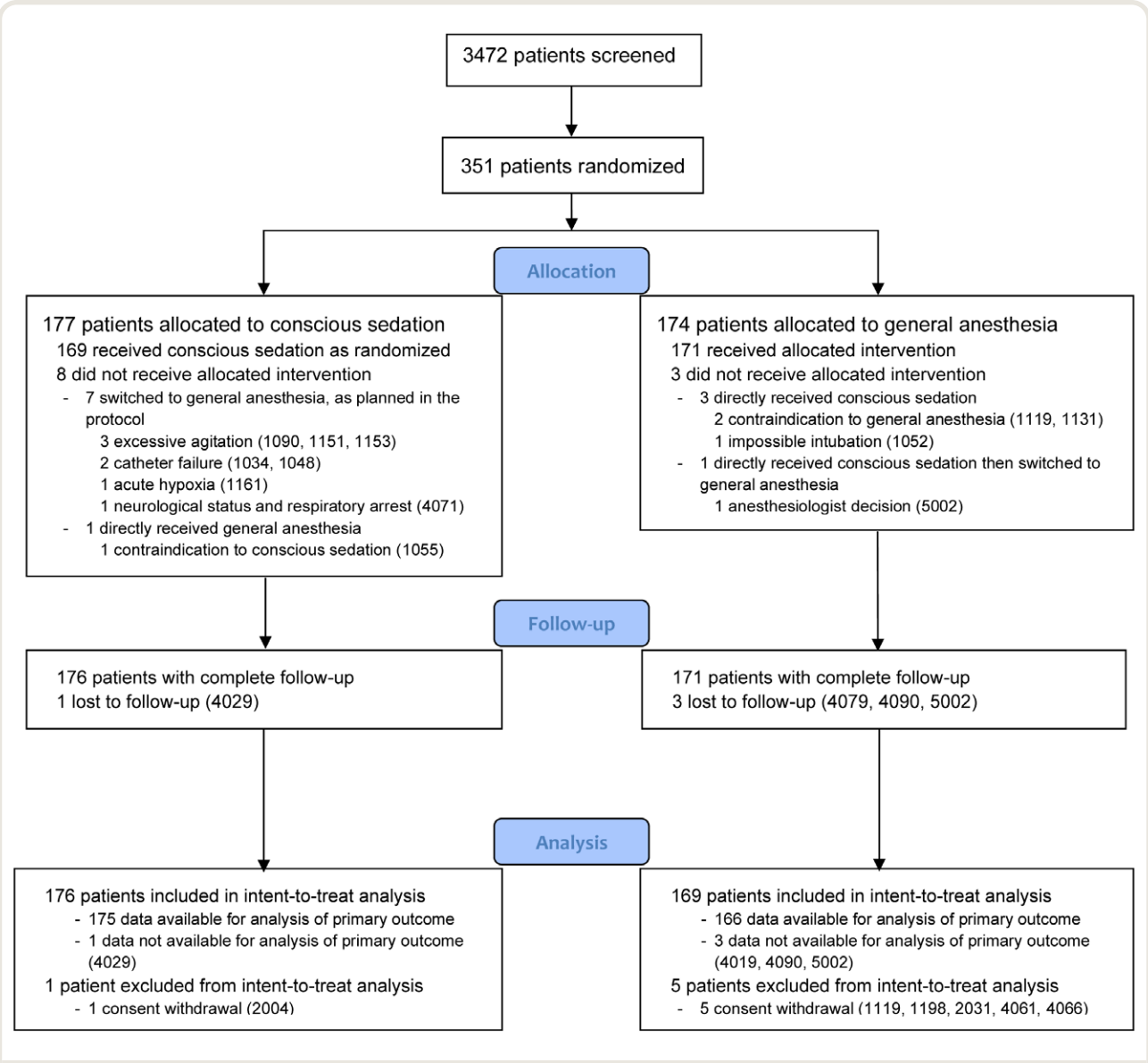

Fig. 1. Flow of participants through the study.

The first three randomized trials comparing general anesthesia and sedation reported similar outcomes with conscious sedation or general anesthesia in a total of 368 patients.[11–13] For the Sedation *vs.* Intubation for Endovascular Stroke Treatment (SIESTA) trial, Schönenberger *et al.*[11] reported that the single-center study outcome at 24 h and 3 months was similar for both techniques; functional outcome at 3 months was only a secondary outcome. However, the anesthesia protocol was not detailed, and the definitions of *general anesthesia* and *conscious sedation* were not clearly stated. Indeed, the design allowed patients benefitting from conscious sedation to receive analgesics and/or sedatives if necessary, which could then transform the sedation into light general anesthesia.

In the Anesthesia During Stroke (AnStroke) trial, Löwhagen *et al.*[12] also reported no differences between the two techniques on outcome at 3 months after endovascular treatment using a detailed anesthesia protocol; however, the study was a single-center study that included only 90 patients. In the General or Local Anesthesia in Intraarterial Therapy (GOLIATH) trial, Simonsen *et al.*[13] used an identical design with infarct growth as the primary endpoint and reported no differences; however, clinical outcome at 90 days, tested as a secondary endpoint, was better in patients who benefitted from general anesthesia. A *post hoc* analysis showed that safety of endovascular treatment and reperfusion was also similar under general anesthesia or conscious sedation.[14] Meta-analyses have reported controversial results. One meta-analysis analyzing the pooled data of

Table 1. Characteristics of Patients

Characteristic	Conscious Sedation	General Anesthesia	Standardized Difference (95% CI)
Age, yr*	72.6 ± 12.3	70.8 ± 13.0	–0.13 (–0.35 to 0.07)
Sex, female*	77 (44)	80 (47)	–0.07 (–0.28 to 0.14)
Body mass index, kg/m²†	26 ± 4	26 ± 5	0.02 (–0.19 to 0.23)
Heart rate, beats/min‡	77 ± 18	81 ± 20	0.21 (–0.01 to 0.42)
Arterial blood pressure, mmHg§			
Systolic	151 ± 24	147 ± 27	–0.18 (–0.39 to 0.04)
Diastolic	83 ± 15	81 ± 18	–0.11 (–0.32 to 0.10)
Mean	106 ± 15	103 ± 19	–0.16 (–0.37 to 0.05)
Medical history*			
Atrial fibrillation	55 (32)	52 (31)	–0.01 (–0.22 to 0.21)
Hypertension	124 (70)	97 (57)	–0.27 (–0.49 to –0.06)
Diabetes mellitus	27 (15)	22 (13)	–0.07 (–0.28 to 0.14)
Myocardial infarction	8 (5)	4 (2)	–0.12 (–0.33 to 0.09)
Peripheral arterial disease	14 (8)	9 (5)	–0.11 (–0.32 to 0.11)
Previous stroke*	23 (13)	22 (13)	–0.00 (–0.21 to 0.21)
Antihypertension treatment*	132 (75)	107 (64)	–0.24 (–0.46 to –0.03)
Conversion enzyme inhibitors/angiotensin-converting enzyme inhibitors	87 (66)	62 (58)	–0.16 (–0.42 to 0.09)
β-Blocker	82 (62)	72 (67)	0.11 (–0.15 to 0.36)
Anticoagulant*	40 (23)	24 (14)	–0.22 (–0.43 to –0.01)
Vitamin K antagonist	20 (50)	10 (42)	–0.17 (–0.67 to 0.34)
Rivaroxaban/apixaban/dabigatran	16 (40)	10 (42)	0.03 (–0.47 to 0.54)
Heparin	2 (5)	4 (10)	0.38 (–0.13 to 0.89)
Antiaggregant*	49 (28)	50 (30)	–0.22 (–0.43 to –0.01)

Data are presented as mean ± SD for continuous variables and frequency (%) for categorical variables. Heart rate and blood pressure were assessed during the preoperative consultation.

*Data were available for 176 patients in the conscious sedation group and 169 in the general anesthesia group. †Data were available for 166 patients in the conscious sedation group and 156 in the general anesthesia group. ‡Data were available for 155 patients in the conscious sedation group and 151 in the general anesthesia group. §Data were available for 165 patients in the conscious sedation group and 154 in the general anesthesia group.

Table 2. Stroke Characteristics

Characteristic	Conscious Sedation	General Anesthesia
Time from stroke onset to admission in emergency department, min*	88 ± 53	89 ± 57
Time from stroke onset to admission in stroke center, min*	266 ± 79	257 ± 70
National Institutes of Health Stroke Scale score on admission†	16 ± 5	16 ± 6
Intracranial arterial occlusion ‡		
Intracranial internal carotid artery only	14 (8)	23 (14)
First middle cerebral artery segment only	109 (62)	99 (59)
Second middle cerebral artery segment only	21 (12)	19 (11)
Other segment	1 (0.6)	0 (0)
Tandem occlusion	31 (18)	28 (17)
Localization of stroke in left hemisphere ‡	90 (51)	84 (50)
IV thrombolysis‡	114 (65)	111 (66)

Data are presented as mean ± SD for continuous variables and frequency (%) for categorical variables.

*Data were available for 155 patients in the conscious sedation group and 148 in the general anesthesia group. †Data were available for 173 patients in the conscious sedation group and 167 in the general anesthesia group. ‡Data were available for 176 patients in the conscious sedation group and 169 in the general anesthesia group.

IV, intravenous.

seven trials[8] reported that outcome at 3 months was worse with general anesthesia; however, some trials included in this meta-analysis did not randomize the choice between general anesthesia and conscious sedation. A second meta-analysis[18] consisting of data analysis of the first three randomized, controlled trials (SIESTA, AnStroke, and GOLIATH) reported an opposing conclusion, with general anesthesia being associated with less disability at 3 months; however, as noted, the three included trials were single-center, and outcome at 3 months was not the primary outcome for two of three.

The DEFUSE study found that patients who underwent thrombectomy with conscious sedation experienced

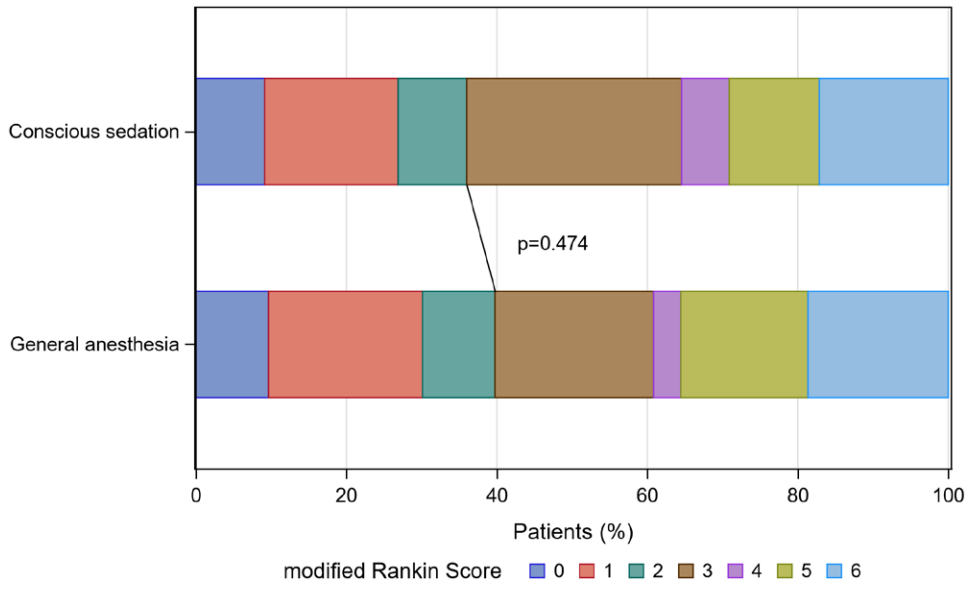

Fig. 2. Neurologic outcome expressed as modified Rankin score.

increased likelihood of functional independence at 90 days and lower National Institutes of Health Stroke Scale scores at 24 h[10]; however, the choice between general anesthesia and conscious sedation was left to the discretion of the team, and protocols were neither detailed nor standardized.[10] The difference between profound conscious sedation and light general anesthesia has not always been clearly identified in previous studies.[11] Recent data from the German Stroke Registry favored conscious sedation over general anesthesia with a better functional outcome[9]; however, neither general anesthesia and conscious sedation protocols nor intraprocedural hemodynamic management was reported. Unlike most previous studies, a standardized anesthesia protocol was applied in both groups in our study and resulted in a similar outcome evaluated *via* modified Rankin score at 3 months.

Moreover, the hemodynamic control during the procedure was also standardized in our study despite the lack of clear and detailed recommendations in the literature. European guidelines call for avoiding excessive systolic blood pressure drops during thrombectomy without any further details.[19] A *post hoc* analysis of the GOLIATH study[20] reported that hemodynamics during the procedure did not have any impact on the outcome after endovascular treatment for stroke. A *post hoc* analysis of the first three randomized trials (SIESTA, AnStroke, and GOLIATH), however, reported that mean arterial blood pressure less than 70 mmHg for more than 10 min or greater than 90 mmHg for more than 45 min were both critical and associated with poor functional outcome after endovascular treatment for stroke.[21] In our study, despite a standardized hemodynamic control for both groups, patients in the general anesthesia group experienced more episodes of hypo- and hypertension; however, the cumulative duration of hypotension and outcome at 3 months was similar in both groups. Proper attention to cumulative time within preset hemodynamic ranges is possible with either technique. Indeed, general anesthesia associated with a standardized and well-known hemodynamic control protocol was as safe as conscious sedation.

One factor alone (*i.e.,* type of anesthesia or hemodynamics) is probably not defining the functional outcome at 3 months, however, and a combination of many factors is probably involved. In our study, despite the incidence of technical failure of endovascular therapy being greater in the conscious sedation group while recanalization was better in the general anesthesia group, the outcome was similar in both groups. In other words, patients in the conscious sedation group experienced more technical failure, while patients in the general anesthesia group experienced more hypo- and hypertensive episodes and better recanalization, but these differences did not influence outcome.

There are several limitations to our study. First, the primary outcome was scheduled to be assessed 3 months after treatment; however, it was actually assessed in a wider timeframe (between 2 and 6 months after treatment) for logistic reasons. Second, a systematic, day 1, post–endovascular treatment computed tomography scan or magnetic resonance image assessing Alberta Stroke Program Early CT (ASPECT) score was not originally scheduled[17] because it was not standard practice at the time of study design. The systematic post–endovascular treatment cone-beam

Table 3. Secondary Outcomes

	Conscious Sedation	General Anesthesia	Mean/Median/Risk Difference (95% CI)	*P* Value
Time from stroke onset to groin puncture, min*	248 ± 92	269 ± 85	−20 (−39 to −01)	0.040
Time from arrival at stroke center to groin puncture, min*	60 ± 39	69 ± 44	−10 (−19 to −01)	0.037
Time from stroke onset to recanalization, min*	307 ± 87	320 ± 96	−13 (−33 to 07)	0.203
Modified Thrombolysis in Cerebral Ischemia grade 2b–3†	131 (75)	144 (85)	−10 (−18 to −2)	0.021
National Institutes of Health Stroke Scale score				
Day 1	11 ± 7	11 ± 9	0 (−2 to 1)	0.623
Day 7	8 ± 7	8 ± 7	−1 (−2 to 1)	0.417
Arterial complications‡	13 (8)	9 (5)	2 (−3 to 7)	0.418
Perforation	9 (5)	7 (4)	1 (−4 to 6)	0.652
Dissection	3 (2)	2 (1)	0 (−2 to 3)	> 0.999
Clot migration	1 (0.6)	0 (0)	1 (−1 to 2)	> 0.999
Symptomatic intracerebral hemorrhage	42 (24)	37 (22)	2 (−7 to 11)	0.642
Mortality at 3 months§	28 (16)	31 (19)	−3 (−11 to 5)	0.514
Remifentanil, ng/ml‖	1.4 ± 0.7	2.6 ± 1.1	−1.2 (−1.5 to −1.0)	< 0.0001
Intraoperative ephedrine administration#	9 (5)	36 (22)	−17 (−24 to −9)	< 0.0001
Intraoperative ephedrine doses, mg#	13 ± 6	13 ± 9	−1 (−6 to 6)	0.986
Norepinephrine**	99 (57)	157 (95)	−37 (−46 to −30)	< 0.0001
Duration of norepinephrine administration, h**	1:00 (0:35 to 2:05)	1:27 (0:50 to 3:00)	−00:18 (−00:35 to 00:00)	0.024
Norepinephrine doses >1 mg/h**	25 (26)	74 (47)	−22 (−34 to −10)	0.0005
Intraoperative hemodynamics††				
Episode(s) of hypotension	1 (1 to 2)	2 (1 to 2)	0 (−1 to 0)	0.001
≥ 1 episode of hypotension	129 (77)	163 (100)	−23 (−30 to −17)	< 0.0001
Cumulative duration of hypotension, min	36 ± 31	39 ± 25	−2 (−9 to 4)	0.079
Episode(s) of hypertension	0 (0 to 0)	0 (0 to 1)	0 (0 to 0)	0.033
≥ 1 episode of hypertension	33 (20)	49 (31)	−11 (−20 to −1)	0.030
Cumulative duration of hypertension, min	8 ± 7	11 ± 12	−1 (−5 to 4)	0.739
Intraoperative antihypertension treatment	22 (12)	19 (11)	−1 (−6 to 8)	0.749
Hemodynamics within first 24 h‡‡				
Episode(s) of hypotension	2 (1 to 3)	2 (1 to 2)	0 (0 to 1)	0.480
≥ 1 episode of hypotension	36 (31)	38 (33)	−2 (−14 to 10)	0.744
≥ 1 episode of hypertension	30 (26)	34 (29)	−4 (−15 to 8)	0.530
Cumulative duration of hypotension, min	218 ± 200	228 ± 324	−11 (−136 to 115)	0.867
Episode(s) of hypertension	1.5 (1 to 2)	1 (1 to 2)	0 (0 to 0)	0.105
Cumulative duration of hypertension, min	81 ± 83	71 ± 74	10 (−29 to 49)	0.611

Data are presented as mean ± SD for continuous variables, frequency (%) for categorical variables, or median (interquartile range). Hypotension was defined as systolic blood pressure < 140 mmHg, or mean blood pressure drop ≥ 40%. Hypertension was defined as systolic blood pressure > 185 mmHg or diastolic blood pressure > 110 mmHg. A modified Thrombolysis in Cerebral Ischemia grade of 2b to 3 was considered successful recanalization.

*Data were available on 168 patients in the conscious sedation group and 163 in the general anesthesia group. †Data were available on 174 patients in the conscious sedation group and 169 in the general anesthesia group. ‡Data were available on 170 patients in the conscious sedation group and 165 in the general anesthesia group. §Data were available on 175 patients in the conscious sedation group and 166 in the general anesthesia group. ‖Data were available on 170 patients in the conscious sedation group and 157 in the general anesthesia group. #Data were available on 172 patients in the conscious sedation group and 165 in the general anesthesia group. **Data were available on 173 patients in the conscious sedation group and 165 in the general anesthesia group. ††Data were available on 168 patients in the conscious sedation group and 163 in the general anesthesia group. ‡‡Data were available on 117 patients in the conscious sedation group and 116 in the general anesthesia group.

computed tomography used during the study did not have enough spatial resolution to evaluate day 1 ASPECT scores, only immediate postoperative bleeding transformation of the stroke. Third, the number of patients with good functional outcome was lower and mortality rate was higher in our study when compared with previous studies, especially with the Trial and Cost Effectiveness Evaluation of Intraarterial Thrombectomy in Acute Ischemic Stroke (THRACE) study[22]; however, our study's population was also older than the THRACE study's.

In summary, among patients undergoing endovascular treatment for stroke, the functional outcome at 3 months was similar in patients receiving conscious sedation or general anesthesia. Patients in the conscious sedation group experienced more technical failures, while patients in the general anesthesia group experienced more hypo-/hypertensive episodes and better recanalization, but these differences did not influence outcome. From a practical point of view, physicians may favor general anesthesia because the outcome is similar to that of conscious sedation, which is associated with more technical failure and may be less comfortable for the neuroradiologist. General anesthesia could also be associated with complications like difficult airway management. The choice between the two techniques should therefore be personalized to each patient.

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Competing Interests

Dr. Beloeil received speaking fees from AbbVie (Chicago, Illinois) and Aspen Pharmacare (Durban, South Africa) and is a member of an expert board for Orion Pharma (Espoo, Finland). The other authors declare no competing interests.

Reproducible Science

Full protocol available at: helene.beloeil@chu-rennes.fr. Raw data available at: helene.beloeil@chu-rennes.fr.

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Appendix

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