Stroke

CLINICAL AND POPULATION SCIENCES

General Anesthesia Versus Conscious Sedation and Local Anesthesia During Thrombectomy for Acute Ischemic Stroke

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BACKGROUND AND PURPOSE: As numerous questions remain about the best anesthetic strategy during thrombectomy, we assessed functional and radiological outcomes in stroke patients treated with thrombectomy in presence of general anesthesia (GA) versus conscious sedation (CS) and local anesthesia (LA).

METHODS: We conducted a cohort study on prospectively collected data from 4429 patients enrolled in the Italian Registry of Endovascular Treatment in Acute Stroke.

RESULTS: GA was used in 2013 patients, CS in 1285 patients, and LA in 1131 patients. The rates of 3-month modified Rankin Scale score of 0–1 were 32.7%, 33.7%, and 38.1% in the GA, CS, and LA groups: GA versus CS: odds ratios after adjustment for unbalanced variables (adjusted odds ratio [aOR]), 0.811 (95% CI, 0.602–1.091); and GA versus LA: aOR, 0.714 (95% CI, 0.515–0.990). The rates of modified Rankin Scale score of 0–2 were 42.5%, 46.6%, and 52.4% in the GA, CS, and LA groups: GA versus CS: aOR, 0.902 (95% CI, 0.689–1.180); and GA versus LA: aOR, 0.769 (95% CI, 0.566–0.998). The rates of 3-month death were 21.5%, 19.7%, and 14.8% in the GA, CS, and LA groups: GA versus CS: aOR, 0.872 (95% CI, 0.644–1.181); and GA versus LA: aOR, 1.235 (95% CI, 0.844–1.807). The rates of parenchymal hematoma were 9%, 12.6%, and 11.3% in the GA, CS, and LA groups: GA versus CS: aOR, 0.380 (95% CI, 0.262–0.551); and GA versus LA: aOR, 0.532 (95% CI, 0.337–0.838). After model of adjustment for predefined variables (age, sex, thrombolysis, National Institutes of Health Stroke Scale, onset-to-groin time, anterior large vessel occlusion, procedure time, prestroke modified Rankin Scale score of <1, antiplatelet, and anticoagulant), differences were found also between GA versus CS as regards modified Rankin Scale score of 0–2 (aOR, 0.659 [95% CI, 0.538–0.807]) and GA versus LA as regards death (aOR, 1.413 [95% CI, 1.095–1.823]).

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CONCLUSIONS: GA during thrombectomy was associated with worse 3-month functional outcomes, especially when compared with LA. The inclusion of an LA arm in future randomized clinical trials of anesthesia strategy is recommended.

Key Words: anesthesia ■ conscious sedation ■ groin ■ odds ratio ■ thrombectomy

Mechanical thrombectomy for ischemic stroke with large vessel occlusion substantially reduces disability, with 5 randomized clinical trials leading to guideline changes worldwide.[1–5] However, numerous questions remain about the best practices for mechanical thrombectomy, including which anesthetic strategy results in the best clinical outcomes.

Two previous meta-analyses reported worse 3-month functional outcomes from general anesthesia (GA) than from nongeneral anesthesia (non-GA; composite of conscious sedation [CS] and local anesthesia [LA]) during mechanical thrombectomy,[6,7] while the rates of recanalization success and symptomatic intracerebral hemorrhage (sICH) did not differ.[6,7]

In the last years, the interest has focused on the comparison between GA and CS during mechanical thrombectomy. CS is often considered as the ideal compromise during mechanical thrombectomy by preserving patient cooperation, comfort, and procedural speed compared with LA and reducing medication levels compared with GA. A recent meta-analysis reported that CS was associated with better 3-month functional outcome when compared with GA, while recanalization success and sICH were similar.[8] Similarly, a DEFUSE 3 (Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke) analysis showed that patients who underwent thrombectomy with CS in the extended time window experienced a higher likelihood of 3-month functional independence when compared with those who had GA.[9] However, recently published randomized clinical trials (ie, SIESTA [Sedation vs Intubation for Endovascular Stroke Treatment], ANSTROKE [Anesthesia During Stroke], and GOLIATH [General or Local Anesthesia in Intra-Arterial Therapy])[10–12] comparing GA and CS during mechanical thrombectomy have not confirmed the superiority of CS over GA.

On the other hand, a recently published study reported that CS was associated with poor functional outcome compared with LA.[13] A few studies have also compared the functional outcome between patients treated with LA and GA. A multicenter retrospective registry study demonstrated that clinical outcomes and survival were significantly better in patients treated with LA than with GA.[14] Similarly, data from The Interventional Management of Stroke III trial showed that GA was associated with worse neurological outcomes and increased mortality compared with LA.[15] Recanalization success and sICH were similar between the 2 groups. However, the studies were limited by sample size.

The aim of this study was to assess functional and radiological outcomes in a large cohort of large vessel occlusion–related acute ischemic strokes treated with mechanical thrombectomy in presence of GA versus non-GA, GA versus CS, and GA versus LA.

METHODS

Study Design, Participants, and Procedures

We conducted a cohort study on prospectively collected data of patients enrolled in the IRETAS (Italian Registry of Endovascular Treatment in Acute Stroke). The IRETAS is a multicenter, observational internet-based registry (Table I in the Data Supplement). Acute ischemic stroke patients with large vessel occlusion who received endovascular procedures between January 2011 and December 2017 were included in the present study. Participating centers were required to accept the rules of the IRETAS, including consecutive registration of all stroke patients receiving endovascular procedures irrespective of whether treatment was according to guidelines. Our analysis was conducted according to the STROBE criteria (Strengthening the Reporting of Observational Studies in Epidemiology) for observational studies.[16]

Data Collection

The clinical data were collected by neurologists, whereas the radiological data were collected by neuroradiologists of each center. Data collection is provided in the Supplementary Material in the Data Supplement. The choice of type of anesthesia (ie, GA, CS, LA) and anesthetic agents (ie, type, dosage) was at the discretion of the stroke team (neurologist, neuroradiologist, and anesthesiologist) of each center according to the particular neurological and general conditions of the patient (eg, prehospital tracheal intubation, level of consciousness, aphasia, neglect, dysphagia, agitation, aspiration, vomiting, respiratory failure) and the habits/experience of the individual operator. GA was provided for tracheal intubation and mechanical ventilation and was maintained according to local standards and protocols. CS had the goal of reducing agitation, anxiety, and movements, but allowing communication with the patient, and was performed according to local standards and protocols. LA was achieved by subcutaneous injection of anesthetic at the puncture site.

Inclusion and Exclusion Criteria

We included all patients with age ≥18 years who received mechanical thrombectomy. We excluded patients who received intra-arterial fibrinolysis alone and patients for lacking data on type of anesthesia.

Outcome

The functional outcomes were (1) excellent functional outcome (modified Rankin Scale score of 0–1), (2) favorable functional outcome (modified Rankin Scale score of 0–2), and (3) death at 3 months. The radiological outcomes were (1) successful recanalization (Thrombolysis in Cerebral Infarction grading system 2b/3), (2) complete recanalization (Thrombolysis in Cerebral Infarction grading system 3) after the procedure, (3) any type of intracerebral hemorrhage (ICH), (4) hemorrhagic infarct (HI), (5) parenchymal hematoma (PH), (6) subarachnoid hemorrhage, and (7) sICH (defined as PH with increase of ≥4 National Institutes of Health Stroke Scale score points from baseline or death) within 24 hours.

Statistical Analysis

We performed statistical analyses using SPSS 22.0 statistical package. Continuous variables were reported as median and interquartile range values. Proportions were calculated for categorical variables, dividing the number of events by the total number excluding missing/unknown cases. Statistical significance was established at 2-tailed 0.05 level ($P<0.05$).

We estimated the associations of GA (versus non-GA, versus CS, and versus LA) on outcome measures by calculating the odds ratios (ORs) with 2-sided 95% CI after adjustment for group differences in baseline characteristics (probability value <0.10), including variables with a number of missing values which was less than one-third of the entire cohort.

Propensity score matching of 2 similar groups (GA versus non-GA) was conducted with 1:1 ratio and match tolerance of 0.0005. Five models of propensity score matching were applied to the 2 groups of patients among the cohorts of patients with complete date for 3-month modified Rankin Scale score, Thrombolysis in Cerebral Infarction grading system, ICH, and sICH. The clinical and radiological predictors of the models were identified by 3 neurologists with clinical expertise in the management of stroke according to recent literature.[17–20] Predictors with a number of missing values which was greater than one-third of the entire cohort were excluded. The first

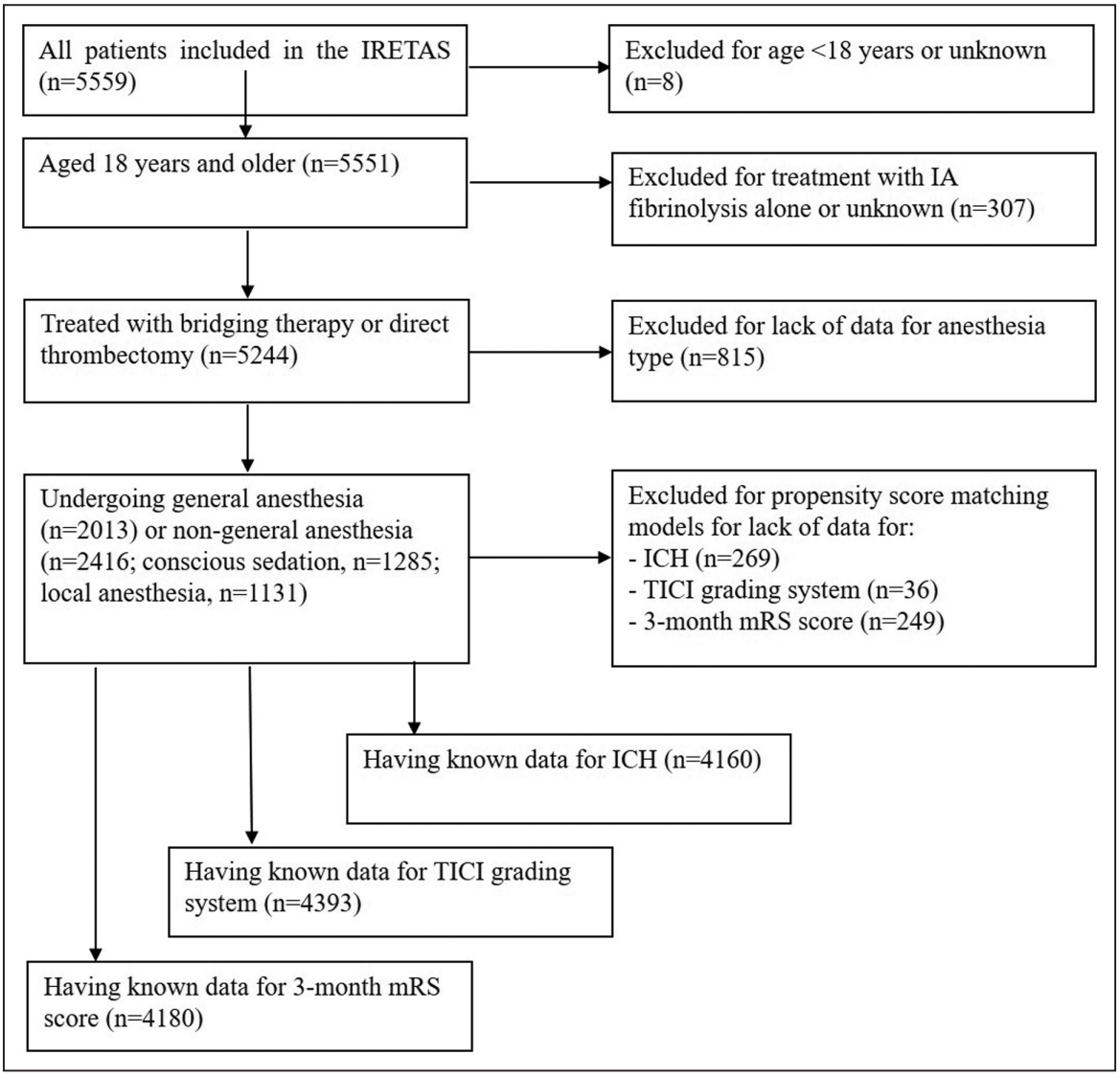

Figure. Flow diagram of included and excluded patients. IA indicates intra-arterial; ICH, intracerebral hemorrhage; IRETAS, Italian Registry of Endovascular Treatment in Acute Stroke; mRS, modified Rankin Scale; and TICI, Thrombolysis in Cerebral Infarction.

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Table 1. Demographics and Clinical Characteristics in the General Anesthesia, Conscious Sedation, and Local Anesthesia Groups

	General Anesthesia (n=2013)	Conscious Sedation (n=1285)	Local Anesthesia (n=1131)	*P* Value
Demographics				
Age (y), median (IQR)	72 (59–79)	74 (63–81)	73 (62–80)	<0.001
Age (y)				<0.001
18–49, n (%)	242 (12)	115 (8.9)	102 (9)	
50–64, n (%)	480 (23.8)	271 (21.1)	234 (20.7)	
65–79, n (%)	928 (46.1)	569 (44.3)	524 (46.3)	
≥80, n (%)	363 (18)	330 (26.7)	271 (24)	
Male sex, n (%)	1107 (55)	606 (47.2)	528 (46.7)	<0.001
Years				
2016–2017, n (%)	1017 (50.5)	811 (63.1)	626 (55.3)	<0.001
Medical history				
Hypertension, n (%)	1086 (65.8) [362]	698 (65.3) [216]	658 (63.1) [89]	0.361
Diabetes mellitus, n (%)	302 (18.3) [362]	167 (15.6) [216]	172 (16.5) [89]	0.169
Hyperlipidemia, n (%)	481 (29.1) [362]	264 (24.7) [216]	247 (23.7) [89]	0.003
Current or past smoking, n (%)	373 (22.6) [362]	203 (19) [216]	209 (20.1) [89]	0.059
Previous stroke/TIA, n (%)	101 (6.1) [362]	61 (5.7) [216]	51 (4.9) [89]	0.408
Atrial fibrillation, n (%)	445 (27) [362]	358 (33.5) [216]	352 (33.8) [89]	<0.001
Coronary heart disease, n (%)	144 (8.7) [362]	123 (11.5) [216]	115 (11) [89]	0.034
Congestive heart failure, n (%)	125 (7.6) [362]	82 (7.7) [216]	60 (5.8) [89]	0.140
Antiplatelet, n (%)	531 (26.4)	368 (28.6)	361 (31.9)	0.004
Oral anticoagulant n (%)	179 (8.9)	134 (10.4)	125 (11.1)	0.112
Statin, n (%)	296 (14.7)	174 (13.5)	188 (16.6)	0.101
Baseline data				
Prestroke mRS score of ≤1, n (%)	1376 (87.4) [438]	958 (86.3) [175]	903 (90.3) [131]	0.015
NIHSS score, median (IQR)	19 (15–22) [181]	18 (14–21) [32]	16 (12–20) [5]	<0.001
NIHSS score				<0.001
≤10, n (%)	226 (12.3) [181]	202 (16.1) [32]	245 (21.8) [5]	
11–15, n (%)	331 (18.1) [181]	268 (21.4) [32]	269 (23.9) [5]	
16–20, n (%)	645 (35.2) [181]	444 (35.4) [32]	349 (31) [5]	
>20, n (%)	630 (34.4) [181]	339 (27.1) [32]	263 (23.4) [5]	
ASPECTS, median (IQR)	10 (8–10) [644]	10 (9–10) [189]	10 (9–10) [150]	<0.001
ASPECT score of ≥6, n (%)	1285 (93.9) [644]	1057 (96.4) [189]	963 (98.2) [150]	<0.001
Occlusion site				<0.001
Tandem, n (%)	261 (13.1) [25]	172 (13.4) [2]	159 (14.1) [3]	
Intracranial ICA, n (%)	410 (20.6) [25]	245 (19.1) [2]	171 (15.2) [3]	
M1-segment MCA, n (%)	724 (36.4) [25]	598 (46.6) [2]	559 (49.6) [3]	
M2-segment MCA, n (%)	152 (7.6) [25]	171 (13.3) [2]	170 (15.1) [3]	
Vertebrobasilar arteries, n (%)	441 (22.2) [25]	97 (7.6) [2]	69 (6.1) [3]	
Good collateral circulation, n (%)	569 (64.8) [1135]	326 (62.7) [765]	327 (75.3) [697]	<0.001
IV thrombolysis, n (%)	952 (47.4) [4]	678 (52.9) [4]	581 (51.5) [2]	0.004
Onset-to-groin time (min), median (IQR)	240 (185–300) [130]	220 (170–289) [89]	235 (180–300) [88]	<0.001
Onset-to-groin time				<0.001
≤180 min, n (%)	412 (21.9) [130]	356 (29.8) [89]	248 (23.8) [88]	
181–360 min, n (%)	1183 (62.8) [130]	707 (59.1) [89]	686 (65.8) [88]	
6–16 h, n (%)	269 (14.3) [130]	126 (10.5) [89]	95 (9.1) [88]	
16–24 h, n (%)	19 (1) [130]	7 (0.6) [89]	14 (1.3) [88]	

(*Continued*)

Table 1. Continued

	General Anesthesia (n=2013)	Conscious Sedation (n=1285)	Local Anesthesia (n=1131)	*P* Value
Type of procedure				<0.001
Aspiration alone, n (%)	611 (47.5) [727]	454 (47.4) [328]	320 (34.4) [201]	
Stent retriever alone, n (%)	443 (34.4) [727]	322 (33.6) [328]	476 (51.2) [201]	
Combination of aspiration and stent retriever, n (%)	232 (18) [727]	181 (18.9) [328]	134 (14.4) [201]	
Additional IA fibrinolysis, n (%)	181 (9)	89 (6.9)	142 (12.6)	<0.001
Single thrombectomy device pass, n (%)	579 (48.9) [830]	481 (53.1) [380]	508 (58.7) [266]	<0.001
Procedure time (min), median (IQR)	75 (50–109) [60]	65 (44–96) [24]	70 (45–105) [1]	<0.001
Procedure time (min) ≤60, n (%)	740 (37.9) [60]	599 (47.5) [24]	490 (43.4) [1]	<0.001
Functional outcome measures				
mRS score of 0–1, n (%)	617 (32.7) [124]	404 (33.7) [86]	416 (38.1) [39]	0.009
mRS score of 0–2, n (%)	803 (42.5) [124]	559 (46.6) [86]	572 (52.4) [39]	<0.001
Death, n (%)	406 (21.5) [124]	236 (19.7) [86]	162 (14.8) [39]	<0.001
Radiological outcome measures				
TICI 3, n (%)	860 (43.1) [18]	572 (44.9) [12]	448 (39.8) [6]	0.038
TICI 2b/3, n (%)	1509 (75.6) [18]	934 (73.4) [12]	883 (78.5) [6]	0.014
Any ICH, n (%)	398 (22.1) [212]	341 (27.3) [37]	328 (29.5) [20]	<0.001
HI, n (%)	210 (11.7) [212]	180 (14.4) [37]	198 (17.8) [20]	<0.001
PH, n (%)	162 (9) [212]	157 (12.6) [37]	125 (11.3) [20]	0.005
SAH, n (%)	68 (3.8) [212]	25 (2) [37]	29 (2.6) [20]	0.013
sICH, n (%)	37 (2.2) [344]	26 (2.2) [77]	36 (3.3) [35]	0.140

ASPECTS indicates Alberta Stroke Program Early CT Score; HI, hemorrhagic infarct; IA, intra-arterial; ICA, internal carotid artery; ICH, intracerebral hemorrhage; IQR, interquartile range; IV, intravenous; MCA, middle cerebral artery; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; SAH, subarachnoid hemorrhage; sICH, symptomatic intracerebral hemorrhage; TIA, transient ischemic attack; and TICI, Thrombolysis in Cerebral Infarction.

model included age (18–49, 50–64, 65–79, or ≥80 years), sex, National Institutes of Health Stroke Scale score (≤10, 11–15, 16–20, or >20), intravenous thrombolysis, and onset-to-groin time (≤180, 181–360, or >360 minutes). The second included variables of the first model plus large vessel occlusion in the anterior circulation and procedure time (≤60 or >60 minutes). The third model included variables of the second model plus prestroke modified Rankin Scale score of <1, antiplatelet, and oral anticoagulant. The fourth model included variables of the third model plus side of occlusion and ASPECTS (Alberta Stroke Program Early CT Score) of ≥6. The fifth model included variables of the fourth model plus additional intra-arterial fibrinolysis and single thrombectomy device pass.

We calculated the ORs (95% CI) of GA (versus CS and versus LA) for each outcome measure after the application of 5 models of adjustment including the same predefined variables of the 5 models of propensity score matching used for GA versus non-GA.

Standard Protocol Approvals, Registrations, and Patient Consents

Need for ethical approval or patient consent for participation in the IRETAS varied among participating hospitals. Ethical approval and informed consent were obtained when required.

Data Availability Statement

Anonymized data will be shared by request from any qualified investigator.

RESULTS

Among 5559 patients registered in the IRETAS cohort by 44 centers (Table II in the Data Supplement), 4429 patients (n=2013, GA; n=2416, non-GA) were included in the study. Flow diagram of patient inclusion and exclusion is provided in the Figure. The clinical characteristics of the GA (n=1881, GA started before procedure; n=132, GA started during procedure after conversion from CS or LA), CS (n=1285), and LA (n=1131) groups are provided in Table 1.

Unbalanced variables between GA and non-GA groups are provided in Table III in the Data Supplement. After adjustment for unbalanced variables (age, sex, years 2016–2017, diabetes mellitus, hyperlipidemia, current or past smoking, atrial fibrillation, coronary heart disease, antiplatelet, oral anticoagulant, National Institutes of Health Stroke Scale score, ASPECTS, occlusion site, intravenous thrombolysis, onset-to-groin time, type of procedure, single thrombectomy device pass, and procedure time), a significant difference was found between GA and non-GA groups as regards excellent functional outcome (32.7% versus 35.8%; adjusted OR (aOR), 0.761 [95% CI, 0.597–0.970]), favorable functional outcome (42.5% versus 49.4%; aOR, 0.799 [95% CI, 0.640–0.996]), any ICH (22.1% versus 28.4%; aOR, 0.584 [95% CI, 0.468–0.729]), HI (11.7% versus 16%; aOR, 0.736 [95% CI,

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0.566–0.957]), and PH (9% versus 12%; aOR, 0.484 [95% CI, 0.355–0.659]) (Table IV in the Data Supplement).

Outcome measures in GA and non-GA groups after the application of the 5 models of propensity score are summarized in Table V in the Data Supplement. GA (versus non-GA) group had a higher rate of death according to the first model (20.5% versus 17.3%, *P*=0.028) (Table VI in the Data Supplement); lower rates of any ICH, HI, and PH according to the first (22.4% versus 30.7%, *P*<0.001; 12% versus 17.4%, *P*<0.001; 9.2% versus 12.8%, *P*=0.003), the second (24.4% versus 30.6%, *P*=0.001; 13.8% versus 17.6%, *P*=0.008; 9.8% versus 12.6%, *P*=0.032), and the fourth (23.6% versus 33.1%, *P*<0.001; 14.2% versus 20.6%, *P*=0.002; 8.3% versus 12.6%, *P*=0.010) models (Tables VI, VII, and VIII in the Data Supplement); lower rates of excellent and favorable functional outcome according to the third (28.4% versus 33.1%, *P*=0.030; 40.1% versus 47.2%, *P*=0.002) and the fourth (27.7% versus 33.2%, *P*=0.026; 40.7% versus 46.8%, *P*=0.020) models (Tables VIII and IX in the Data Supplement); a lower rate of favorable functional outcome according to the fifth model (40.8% versus 50.8%, *P*=0.028) (Table X in the Data Supplement); a lower rate of any ICH according to the third (24.4% versus 29.3%, *P*=0.018) and the fifth (22.5% versus 30.3%; *P*=0.049) models (Tables IX and X in the Data Supplement); and a lower rate of HI according to the fifth model (12.7% versus 21%; *P*=0.015) (Table X in the Data Supplement).

After excluding 132 patients who started GA during the procedure, associations between GA (versus non-GA) and outcome measures after adjustment for unbalanced variables are provided in Table XI in the Data Supplement. Associations between GA (versus non-GA) and outcome measures after 5 models of adjustment for predefined variables are provided in Table XII in the Data Supplement.

Unbalanced variables between GA and CS groups are provided in Table XIII in the Data Supplement. Unbalanced variables between GA and LA groups are provided in Table XIV in the Data Supplement. Associations between GA (versus CS and LA) and outcome measures after adjustment for unbalanced variables are provided in Table 2. A significant difference was found between GA and CS groups as regards any ICH (22.1% versus 27.3%; aORs, 0.591 [95% CI, 0.452–0.773]) and PH (9% versus 12.6%; aORs, 0.380 [95% CI, 0.262–0.551]). A significant difference was found between GA and LA groups as regards excellent functional outcome (32.7% versus 38.1%; aOR, 0.714 [95% CI, 0.515–0.990]), favorable functional outcome (42.5% versus 52.4%; aOR, 0.769 [95% CI, 0.566–0.998]), any ICH (22.1% versus 29.5%; aOR, 0.539 [95% CI, 0.398–0.730]), HI (11.7% versus 17.8%; aOR, 0.561 [95% CI, 0.395–0.797]), and PH (9% versus 11.3%; aOR, 0.532 [95% CI, 0.337–0.838]).

Associations between GA (versus CS and LA) and outcome measures after 5 models of adjustment for predefined variables are provided in Table 3. A significant difference was found between GA and CS groups as regards HI (11.7% versus 14.4%) according to the first (aOR, 0.778 [95% CI, 0.620–0.978]) and the fifth (aOR, 0.691 [95% CI, 0.500–0.593]) models and favorable

Table 2. Associations of General Anesthesia (Versus Conscious Sedation and Local Anesthesia) With Outcome Measures After Adjustment for the Unbalanced Variables

	N (%)		OR (95% CI)
mRS score of 0–1			
GA vs CS	617 (32.7)	404 (33.7)	0.811 (0.602–1.091)
GA vs LA	617 (32.7)	416 (38.1)	0.714 (0.515–0.990)*
mRS score of 0–2			
GA vs CS	803 (42.5)	559 (46.6)	0.902 (0.689–1.180)
GA vs LA	803 (42.5)	572 (52.4)	0.769 (0.566–0.998)*
Death			
GA vs CS	406 (21.5)	236 (19.7)	0.872 (0.644–1.181)
GA vs LA	406 (21.5)	162 (14.8)	1.235 (0.844–1.807)
TICI 3			
GA vs CS	860 (43.1)	572 (44.9)	1.094 (0.855–1.399)
GA vs LA	860 (43.1)	448 (39.8)	0.741 (0.557–1.101)
TICI 2b/3			
GA vs CS	1509 (75.6)	934 (73.4)	1.273 (0.963–1.983)
GA vs LA	1509 (75.6)	883 (78.5)	0.929 (0.670–1.287)
Any ICH			
GA vs CS	398 (22.1)	341 (27.3)	0.591 (0.452–0.773)*
GA vs LA	398 (22.1)	328 (29.5)	0.539 (0.398–0.730)*
HI			
GA vs CS	210 (11.7)	180 (14.4)	0.867 (0.627–1.200)
GA vs LA	210 (11.7)	198 (17.8)	0.561 (0.395–0.797)*
PH			
GA vs CS	162 (9)	157 (12.6)	0.380 (0.262–0.551)*
GA vs LA	162 (9)	125 (11.3)	0.532 (0.337–0.838)*
SAH			
GA vs CS	68 (3.8)	25 (2)	2.230 (0.901–4.932)
GA vs LA	68 (3.8)	29 (2.6)	1.158 (0.548–2.445)
sICH			
GA vs CS	37 (2.2)	26 (2.2)	0.661 (0.321–1.363)
GA vs LA	37 (2.2)	36 (3.3)	0.548 (0.246–1.220)

ORs of GA (vs CS) were adjusted for the following unbalanced variables: age, sex, years 2016–2017, diabetes mellitus, hyperlipidemia, current or past smoking, atrial fibrillation, coronary heart disease, NIHSS score, ASPECTS, occlusion site, intravenous thrombolysis, onset-to-groin time, additional intra-arterial fibrinolysis, single thrombectomy device pass, and procedure time. ORs of GA (vs LA) were adjusted for the following unbalanced variables: age, sex, years 2016–2017, hyperlipidemia, atrial fibrillation, coronary heart disease, congestive heart failure, antiplatelet, oral anticoagulant, prestroke mRS score of ≤1, NIHSS score, ASPECTS, occlusion site, intravenous thrombolysis, onset-to-groin time, type of procedure, additional intra-arterial fibrinolysis, single thrombectomy device pass, and procedure time. ASPECTS indicates Alberta Stroke Program Early CT Score; CS, conscious sedation; GA, general anesthesia; HI, hemorrhagic infarct; ICH, intracerebral hemorrhage; LA, local anesthesia; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; PH, parenchymal hematoma; SAH, subarachnoid hemorrhage; sICH, symptomatic intracerebral hemorrhage; and TICI, Thrombolysis in Cerebral Infarction.

*Statistical significance was established at 2-tailed 0.05 level (*P*<0.05).

Table 3. Associations of General Anesthesia (Versus Conscious Sedation and Local Anesthesia) With Outcome Measures After Adjustment for Predefined Variables Including in the 5 Models

	N (%)		Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)	Model 5 OR (95% CI)
mRS score of 0–1							
GA vs CS	617 (32.7)	404 (33.7)	1.056 (0.886–1.259)	1.108 (0.921–1.332)	0.818 (0.664–1.009)	0.862 (0.679–1.094)	0.777 (0.574–1.051)
GA vs LA	617 (32.7)	416 (38.1)	0.935 (0.781–1.119)	0.960 (0.795–1.159)	0.755 (0.611–0.934)*	0.702 (0.553–0.890)*	0.706 (0.521–0.958)*
mRS score of 0–2							
GA vs CS	803 (42.5)	559 (46.6)	0.912 (0.771–1.078)	0.956 (0.802–1.140)	0.768 (0.631–0.935)*	0.800 (0.642–0.992)*	0.732 (0.556–0.962)*
GA vs LA	803 (42.5)	572 (52.4)	0.769 (0.646–0.915)*	0.784 (0.654–0.941)*	0.659 (0.538–0.807)*	0.656 (0.524–0.823)*	0.738 (0.555–0.983)*
Death							
GA vs CS	406 (21.5)	236 (19.7)	1.009 (0.824–1.234)	0.944 (0.766–1.164)	1.052 (0.836–1.325)	0.902 (0.701–1.162)	0.955 (0.699–1.304)
GA vs LA	406 (21.5)	162 (14.8)	1.347 (1.075–1.686)*	1.301 (1.032–1.641)*	1.413 (1.095–1.823)*	1.331 (1.005–1.762)*	1.220 (0.858–1.734)
TICI 3							
GA vs CS	860 (43.1)	572 (44.9)	1.086 (0.932–1.264)	1.131 (0.962–1.331)	1.036 (0.868–1.237)	1.069 (0.879–1.302)	1.180 (0.919–1.514)
GA vs LA	860 (43.1)	448 (39.8)	0.893 (0.760–1.048)	0.867 (0.732–1.028)	0.806 (0.671–1.013)	0.784 (0.640–1.018)	0.835 (0.642–1.087)
TICI 2b/3							
GA vs CS	1509 (75.6)	934 (73.4)	1.136 (0.955–1.350)	1.210 (0.991–1.456)	1.120 (0.915–1.369)	1.102 (0.884–1.374)	1.455 (0.903–1.936)
GA vs LA	1509 (75.6)	883 (78.5)	0.884 (0.732–1.068)	0.843 (0.691–1.029)	0.825 (0.668–1.020)	0.804 (0.637–1.015)	1.001 (0.738–1.358)
Any ICH							
GA vs CS	398 (22.1)	341 (27.3)	0.714 (0.596–0.855)*	0.759 (0.630–0.914)*	0.803 (0.656–0.982)*	0.676 (0.543–0.842)*	0.567 (0.431–0.746)*
GA vs LA	398 (22.1)	328 (29.5)	0.638 (0.529–0.768)*	0.692 (0.572–0.836)*	0.748 (0.610–0.918)*	0.630 (0.504–0.788)*	0.567 (0.427–0.753)*
HI							
GA vs CS	210 (11.7)	180 (14.4)	0.778 (0.620–0.978)*	0.884 (0.669–1.065)	0.857 (0.672–1.092)	0.775 (0.598–1.005)	0.691 (0.500–0.593)*
GA vs LA	210 (11.7)	198 (17.8)	0.598 (0.477–0.750)*	0.659 (0.524–0.829)*	0.739 (0.580–0.941)*	0.669 (0.515–0.869)*	0587 (0.422–0.816)*
PH							
GA vs CS	162 (9)	157 (12.6)	0.643 (0.500–0.827)*	0.672 (0.520–0.869)*	0.699 (0.521–0.938)*	0.595 (0.435–0.815)*	0.478 (0.324–0.707)*
GA vs LA	162 (9)	125 (11.3)	0.735 (0.561–0.962)*	0.781 (0.594–1.026)	0.753 (0.554–1.022)	0.627 (0.452–0.870)*	0.589 (0.388–0.895)*
SAH							
GA vs CS	68 (3.8)	25 (2)	1.926 (0.993–3.170)	1.919 (0.899–3.209)	1.787 (0.907–3.097)	1.496 (0.833–2.686)	1.277 (0.585–2.785)
GA vs LA	68 (3.8)	29 (2.6)	1.553 (0.952–2.531)	1.459 (0.887–2.399)	1.440 (0.844–2.457)	1.292 (0.731–2.285)	1.147 (0.553–2.379)
sICH							
GA vs CS	37 (2.2)	26 (2.2)	1.235 (0.725–2.106)	1.193 (0.693–2.051)	1.570 (0.807–3.052)	1.501 (0.746–3.021)	1.583 (0.696–3.598)
GA vs LA	37 (2.2)	36 (3.3)	0.810 (0.490–1.340)	0.830 (0.497–1.387)	0.747 (0.426–1.307)	0.672 (0.373–1.209)	0.715 (0.357–1.430)

The model 1 included the following predefined variables: age, sex, intravenous thrombolysis, NIHSS score, and onset-to-groin time. The model 2 included variables of the model 1 plus LVO in the anterior circulation and procedure time. The model 3 included variables of the model 2 plus prestroke mRS score, antiplatelet, and oral anticoagulant. The model 4 included variables of the model 3 plus site occlusion, and ASPECTS. The model 5 included variables of the model 4 plus type of procedure, additional intra-arterial fibrinolysis, and single thrombectomy device pass. ASPECTS indicates Alberta Stroke Program Early CT Score; CS, conscious sedation; GA, general anesthesia; HI, hemorrhagic infarct; ICH, intracerebral hemorrhage; LA, local anesthesia; LVO, large vessel occlusion; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio; PH, parenchymal hematoma; SAH, subarachnoid hemorrhage; sICH, symptomatic intracerebral hemorrhage; and TICI, Thrombolysis in Cerebral Infarction.

*Statistical significance was established at 2-tailed 0.05 level ($P<0.05$).

functional outcome (42.5% versus 46.6%) according to the third (aOR, 0.768 [95% CI, 0.631–0.935]), the fourth (aOR, 0.800 [95% CI, 0.642–0.992]), and the fifth (aOR, 0.732 [95% CI, 0.556–0.962]) models. A significant difference was found between GA and LA groups as regards death (21.5% versus 14.8%) according to the first (aOR, 1.347 [95% CI, 1.075–1.686]), the second (aOR, 1.301 [95% CI, 1.032–1.641]), the third (aOR, 1.413 [95% CI, 1.095–1.823]), and the fourth (aOR, 1.331 [95% CI, 1.005–1.762]) models. All models confirmed a significant difference between GA and CS groups as regards any ICH and PH. All models confirmed a significant difference between GA and LA groups as regards favorable functional outcome, any ICH, and HI. A significant difference was confirmed between GA and LA groups as regards excellent functional outcome according to the third, the fourth, and the fifth models, and with PH according to the first, the fourth, and the fifth models.

DISCUSSION

Our study showed that GA (versus non-GA) during mechanical thrombectomy was significantly associated with lower rates of excellent and favorable functional outcome, any ICH, HI, and PH after adjustment

for unbalanced variables and models of propensity score matching including predefined predictors; however, the rate of sICH was similar between the groups. One model of propensity score matching showed that the rate of death was higher in the GA group. After excluding patients who started GA during the procedure, results were unchanged.

GA (versus CS) during mechanical thrombectomy was associated with lower rates of any ICH and PH after adjustment for unbalanced variables and predefined predictors; however, the rate of sICH was similar between the groups. Two models of adjustment for predefined variables showed that GA was associated also with a lower rate of HI, whereas 3 models showed that GA was associated also with a lower rate of favorable outcome.

GA (versus LA) during mechanical thrombectomy was associated with lower rates of excellent and favorable outcome, any ICH, HI, and PH after adjustment for unbalanced variables and predefined predictors; however, the rate of sICH was similar between the groups. Four models of adjustment for predefined variables showed that GA was associated also with a higher rate of death.

Our study showed that GA during thrombectomy was associated with worse functional outcomes, especially when compared with LA in line with 2 small studies[14,15]; however, the association was not related to an increase of sICH or to a decrease of recanalization success in the GA group. Further studies are needed to identify the underlying mechanisms, such as neurotoxicity according to type and duration of GA, hemodynamic adverse effects, hypocapnic conditions, or extracranial complications during GA, which could explain the association between GA and worse functional outcome.

We are aware that our study has some limitations. First, the present study did not randomize patients by anesthesia type, but it is based on a retrospective analysis of prospectively collected data. Second, the number of missing data for outcome measures and predefined predictors might have influenced the final outcome. Third, reasons for the choice of GA (versus CS or LA) were not recorded; it is likely that these choices were influenced by unmeasurable factors related to individual physician's decision, which might have influenced our key findings. Fourth, data on the type of anesthesia were not collected for the entire patient cohort. Fifth, data on duration of anesthetic exposure and intubation, type of anesthetic agent, and reasons of conversion from LA/CS to GA were not available. Finally, we did not use data of collateral circulation because they were missing in more than half of the patients included in the analyses, whereas data of other possible predictors such as the use of a balloon guide catheter were not systematically collected.

Nevertheless, to the best of our knowledge, the present study included the largest cohort of patients treated with mechanical thrombectomy to assess whether there are differences of GA versus non-GA, GA versus CS, and GA versus LA on a complete panel of functional and radiological outcome measures after adjustment for unbalanced variables and models including predefined variables.

CONCLUSIONS

GA (versus non-GA) during mechanical thrombectomy was associated with worse functional outcomes. GA was associated with a lower rate of favorable outcome when compared with CS, whereas GA was associated with lower rates of excellent and favorable outcome and a higher rate of death when compared with LA. GA was associated with lower rates of intracerebral bleedings; however, the rate of sICH was similar among all the comparison groups. Recanalization success did not differ. Therefore, LA seems to be preferable to GA as anesthetic strategy during thrombectomy. However, the inclusion of an LA arm in future randomized clinical trials of anesthesia strategy is recommended.

ARTICLE INFORMATION

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