JoS JOURNAL OF STROKE

Journal of Stroke 2023;25(3):399-408
https://doi.org/10.5853/jos.2023.00318

Original Article

Anesthetic Management and Outcomes of Endovascular Treatment of Basilar Artery Occlusion: Results From the ATTENTION Registry

Chunrong Tao,[1*] Guangxiong Yuan,[2*] Pengfei Xu,[1*] Hao Wang,[3] Peiyang Zhou,[4] Tingyu Yi,[5] Kai Li,[6] Tao Cui,[7] Jun Gao,[8] Rui Li,[1] Jun Sun,[1] Chao Zhang,[1] Li Wang,[1] Tianlong Liu,[1] Jianlong Song,[1] Yamei Yin,[1] Thanh N. Nguyen,[9,10] Qing Li,[11,12] Wei Hu[1]

[1]Department of Neurology, The First Affiliated Hospital of USTC, Division of Life Sciences and Medicine, University of Science and Technology of China, Hefei, China
[2]Department of Emergency, Xiangtan Central Hospital, Xiangtan, China
[3]Department of Neurology, Linyi People's Hospital, Linyi, China
[4]Department of Neurology, Xiangyang No.1 People's Hospital, Hubei University of Medicine, Xiangyang, China
[5]Department of Neurology, Zhangzhou Affiliated Hospital of Fujian Medical University, Zhangzhou, China
[6]Department of Neurology, Heze Municipal Hospital, Heze, Shandong, China
[7]Department of Neurology, Taihe County People's Hospital, Fuyang, China
[8]Department of Neurology, Nanyang Central Hospital, Nanyang, China
[9]Department of Radiology, Boston Medical Center, Boston University School of Medicine, Boston, MA, USA
[10]Department of Neurology, Boston Medical Center, Boston University School of Medicine, Boston, MA, USA
[11]Department of Laboratory Medicine, The First Affiliated Hospital of USTC, Division of Life Sciences and Medicine, University of Science and Technology of China, Hefei, China
[12]Core Facility Center, The First Affiliated Hospital of USTC, Division of Life Sciences and Medicine, University of Science and Technology of China, Hefei, China

Background and Purpose To examine the clinical and safety outcomes after endovascular treatment (EVT) for acute basilar artery occlusion (BAO) with different anesthetic modalities.

Methods This was a retrospective analysis using data from the Endovascular Treatment for Acute Basilar Artery Occlusion (ATTENTION) registry. Patients were divided into two groups defined by anesthetic modality performed during EVT: general anesthesia (GA) or non-general anesthesia (non-GA). The association between anesthetic management and clinical outcomes was evaluated in a propensity score matched (PSM) cohort and an inverse probability of treatment weighting (IPTW) cohort to adjust for imbalances between the two groups.

Results Our analytic sample included 1,672 patients from 48 centers. The anesthetic modality was GA in 769 (46.0%) and non-GA in 903 (54.0%) patients. In our primary analysis with the PSM-based cohort, non-GA was comparable to GA concerning the primary outcome (adjusted common odds ratio [acOR], 1.01; 95% confidence interval [CI], 0.82 to 1.25; *P*=0.91). Mortality at 90 days was 38.4% in the GA group and 35.8% in the non-GA group (adjusted risk ratio, 0.95; 95% CI, 0.83 to 1.08; *P*=0.44). In our secondary analysis with the IPTW-based cohort, the anesthetic modality was significantly associated with the distribution of modified Rankin Scale at 90 days (acOR: 1.45 [95% CI: 1.20 to 1.75]).

Conclusion In this nationally-representative observational study, acute ischemic stroke patients due to BAO undergoing EVT without GA had similar clinical and safety outcomes compared with patients treated with GA. These findings provide the basis for large-scale randomized controlled trials to test whether anesthetic management provides meaningful clinical effects for patients undergoing EVT.

Keywords Stroke; Endovascular treatment; Basilar artery occlusion; Anesthetic management

Correspondence: Wei Hu
Department of Neurology,
The First Affiliated Hospital of USTC,
Division of Life Sciences and Medicine,
University of Science and Technology
of China, Hefei, China
Tel: +86-551-62284076
E-mail: andinghu@ustc.edu.cn
https://orcid.org/0000-0002-4826-4633

Co-correspondence: Qing Li
Department of Laboratory Medicine,
Core Facility Center,
The First Affiliated Hospital of USTC,
Division of Life Sciences and Medicine,
University of Science and Technology
of China, Hefei, China
Tel: +86-551-62283653
E-mail: liqing-2001@163.com
https://orcid.org/0000-0003-4866-6365

Received: January 27, 2023
Revised: May 11, 2023
Accepted: June 7, 2023

*These authors contributed equally as first author.

Introduction

Recently, two randomized controlled trials have demonstrated the superiority of endovascular treatment (EVT) in acute stroke due to basilar artery occlusion (BAO) compared with standard medical care.[1,2] However, less is known about the optimal anesthetic management during EVT. Anesthetic management usually includes general anesthesia (GA) with intubation, conscious sedation (CS), or local anesthesia (LA). LA/CS is often considered easier and quicker to administer than GA without potential delays in starting the endovascular procedure. GA with endotracheal intubation, on the other hand, can protect the upper airway, thus avoiding hypoxia and aspiration. Moreover, GA has the potential to decrease the risks of intraprocedural complications, including vessel dissection or perforation, which may occur due to patient movement secondary to pain, lack of cooperation, altered mental status, or aphasia during intracranial catheter navigation and clot retrieval.

Several observational studies, including patients with large vessel occlusions in the anterior circulation, suggested that compared to non-GA, GA was associated with worse functional outcomes.[3-9] A meta-analysis of the observational data further suggested that GA was associated with worse functional outcomes. However, selection bias with respect to the choice and timing of anesthetic management may have constrained the group comparisons.[10] Data from randomized controlled trials showed a better outcome after EVT in patients who received GA compared with patients treated with non-GA, however.[11-14]

Several observational studies have investigated the effect of anesthetic management in BAO patients, whereby the clinical and safety outcomes under CS/LA appeared similar or better than GA for stroke due to acute BAO.[15-22] A small exploratory randomized controlled trial including 43 acute posterior circulation stroke patients in the GA group and 44 in the CS group suggested that the occurrence of functional independence at 90 days was not associated with the assignment of anesthetic modality (GA 48.8% vs. CS 54.5%; risk ratio, 0.89; 95% confidence interval [CI], 0.58–1.38).[23]

In this subanalysis of the Endovascular Treatment for Acute Basilar Artery Occlusion (ATTENTION) registry, we aimed to investigate the effects of anesthetic strategies on the clinical and safety outcomes in patients with BAO who underwent EVT.

Methods

Study population

The study population was derived from the ATTENTION registry—an ongoing prospective collaborative clinical registry program that collects data on acute ischemic stroke patients due to BAO. Details of the data collected and their definitions have been described previously.[24] In summary, the ATTENTION registry started in 2017 and collected a standardized dataset of all patients with acute BAO, including a follow-up assessment after 3 months. We included consecutive patients at 48 centers between 2017 and 2021, with available data on anesthesia type and functional status on the modified Rankin Scale (mRS) after 3 months.

Anesthetic management

GA was defined as a state of unconsciousness and needing airway protection (i.e., tracheal intubation, laryngeal mask). Systolic blood pressure was mostly maintained greater than or within 20% of the patient's presenting pressure. Non-GA included conscious sedation or local anesthesia. Conscious sedation was defined as the administration of systemic medication to sedate the patient during the procedure without the need for advanced airway protection. Local anesthesia was defined as administering a local anesthetic at the puncture site (usually lidocaine), without using systemic medication to sedate the patient. The preferred approaches for anesthetic management were at the discretion of the treatment team. Patients who converted from non-GA to GA were included in the GA group.

Outcome measures

The primary outcome measure was the distribution of the mRS score at 90 days, which was assessed by board-certified vascular neurologists as part of usual care for all patients with stroke in all participating centers. Local investigators were instructed to assess the mRS score at 90 days (±14 days) by telephone or face-to-face interview, according to a standardized scheme. The secondary clinical outcomes were as follows: comparisons of mRS scores (0 or 1 vs. 2 to 6; 0 to 2 vs. 3 to 6; 0 to 3 vs. 4 to 6) at 90 days; the National Institutes of Health Stroke Scale (NIHSS) score at 24 hours and at 5 to 7 days (or at time of hospital discharge); successful reperfusion according to the postintervention modified Thrombolysis in Cerebral Infarction (mTICI) score, which ranges from grade 0 (no reperfusion) to grade 3 (complete reperfusion).[25] Successful reperfusion was defined as mTICI 2b or higher.

Safety outcomes were symptomatic intracranial hemorrhage (sICH) and mortality at 90 days. Intracranial hemorrhage (ICH) was classified as symptomatic if the patient had died or had a decline in the NIHSS of at least 4 points, and imaging findings were related to clinical deterioration (Heidelberg criteria).[26]

Statistical analysis

Descriptive statistics were reported according to patients treated with GA or without GA. Continuous variables are expressed as median with interquartile range (IQR). Categorical variables are

https://doi.org/10.5853/jos.2023.00318

expressed as a frequency with a percentage. Standardized mean differences between GA and non-GA groups were calculated to assess the magnitude of the between-group differences.[27]

An imputation procedure was performed under the missing at-random assumption considering all covariates listed in Table 1 and also applied in the distribution of the mRS at 90 days. We performed the multiple imputations by chained equations with predictive mean matching methods for continuous variables and ordered or binary logistic regression models for categorical variables to generate ten complete datasets. All analyses were performed in each dataset separately, and the coefficients were combined by Rubin's rules to create the final estimates.[28]

The multivariable models were adjusted for age, baseline NIHSS, baseline Glasgow Coma Scale (GCS), level of occlusion site, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score (pc-ASPECTS), intravenous thrombolysis, history of atrial fibrillation (AF) and diabetes mellitus, and center-level preference for the GA (defined as the center's proportion of GA for all BAO patients received EVT).

We first assessed the clinical and safety outcomes between patients treated with GA and those with non-GA after balancing prognostically important factors using propensity score matching (PSM) methods.[29] The propensity score was estimated using a multivariable logistic regression model, with the treatment received (GA and non-GA) as the dependent variable and all of the characteristics listed in Table 1 as covariates. Patients treated with GA were matched 1:1 to patients treated with non-GA according to the propensity score, without replacement, using the greedy nearest neighbor matching with a 0.01 caliper (PSM cohort).

We used generalized estimating equations in the PSM cohort to account for the matched pairs after PSM. A model with robust variance was used to compare the dichotomous outcomes: the Poisson distribution and log link function were used to estimate the relative risk or rate ratio. The Gaussian distribution and identity link function was used to estimate the mean difference.[30] To compare the distributions of the mRS scores at 90 days, ordered logistical regression with the shift of the mRS scores toward a better functional outcome (lower mRS score) was used to estimate the common odds ratio.

In the inverse probability of treatment weighting (IPTW) cohort, the treatment effect was estimated with the inversed probability weighted regression adjustment model, which used the inversed propensity score to weight each subject, and adjusted for the weighted regression coefficients to compute the averages of treatment-level predicted outcomes. With the "doubly robust" estimation, this analysis reduces the bias and is less sensitive to misspecification.[31] Using patients treated with GA as the reference group, we derived the relative risk, common odds ratio, and mean difference with their 95% CI based on the averages of the predicted event rates or means.

We further investigated the heterogeneity in treatment effect size for the primary clinical outcome within the following subgroups: history of AF (no vs. yes), baseline NIHSS (<10 vs. ≥10), baseline GCS (<13 vs. ≥13), age (<75 vs. ≥75 years), pc-ASPECTS (<8 vs. ≥8), level of BAO sites (proximal basilar artery, middle basilar artery, distal basilar artery), intravenous thrombolysis (no vs. yes), time from estimated BAO to admission (<6 vs. ≥6 hours), and stroke causative mechanism in the PSM cohort. A multiplicative term was entered into regression models to estimate the significance of the interaction with the treatment assignment.

To test replication of the results of the association between anesthetic modality and clinical outcomes in BAO patients, we also analyzed data from patients who received EVT from the Trial of Endovascular Treatment for Acute Basilar-Artery Occlusion (ATTENTION RCT; including 223 patients in the EVT group).[2] ATTENTION RCT was a multicenter, prospective, randomized, controlled trial of EVT for BAO at 36 centers in China. All patients with the NIHSS at admission ≥10 were assigned, in a 2:1 ratio, within 12 hours after the estimated time of BAO to receive EVT or best medical care (control).

All statistical tests were 2-sided, with *P* values less than 0.05 considered statistically significant. Statistical analyses were conducted in Stata version 17.0 (StataCorp, College Station, TX, USA) and R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

Data availability

Anonymized trial data and analytic methods that support our study findings are available from the principal investigator upon reasonable request.

Standard protocol approvals, registrations, and patient consents

Both the ATTENTION registry and RCT trials were approved by the medical ethics committee of the First Affiliated Hospital of the University of Science and Technology of China (ATTENTION registry 2020KY202, ATTENTION RCT 2021KY011) and all relevant local ethics committees. The ATTENTION registry was registered at www.chictr.org.cn (CTR2000041117). ATTENTION RCT was registered at ClinicalTrials.gov (identifier, NCT04751708). All patients or their legally authorized representatives provided signed informed consent before enrollment.

Table 1. Baseline characteristics according to GA or non-GA before and after PSM

	Before matching			After matching		
	All (n=1,672)	GA (n=769)	Non-GA (n=903)	All (n=1,150)	GA (n=575)	Non-GA (n=575)
Age (yr)	66 (56–73)	65 (56–73)	66 (57–74)	66 (56–74)	66 (57–74)	65 (55–73)
Sex						
Female	526 (31.5)	268 (34.5)	258 (28.8)	349 (30.4)	174 (30.3)	175 (30.4)
Male	1,146 (68.5)	508 (65.5)	638 (71.2)	801 (69.7)	401 (69.7)	400 (69.6)
Baseline pc-ASPECTS*						
≥8	1,495 (89.4)	604 (89.7)	686 (87.5)	1,041 (90.5)	519 (90.3)	522 (90.8)
ASITN/SIR grade†						
0–1	1,403 (83.9)	522 (80.8)	599 (80.5)	970 (84.4)	483 (84)	487 (84.7)
2	196 (11.7)	97 (15.0)	99 (13.3)	132 (11.5)	69 (12.0)	63 (11.0)
3–4	73 (4.4)	27 (4.2)	46 (6.2)	48 (4.2)	23 (4.0)	25 (4.4)
Blood pressure on admission (mm Hg)‡						
Systolic	149 (136–161)	150 (137–165)	147 (135–160)	149 (136–161)	149 (136–161)	149 (136–162)
Diastolic	85 (78–93)	85 (79–95)	84 (78–93)	85 (78–93)	84 (74–93)	85 (78–94)
Baseline NIHSS score§	20 (13–29)	22 (14–30)	20 (12–28)	20 (13–29)	20 (13–29)	21 (12–29)
Baseline GCS score§	7 (5–12)	7 (5–10)	8 (5–12)	7 (5–11)	7 (5–11)	7 (5–11)
Medical history						
Atrial fibrillation‖	456 (27.2)	220 (33.9)	233 (30.7)	318 (27.7)	165 (28.7)	153 (26.6)
Hypertension¶	1,004 (60.1)	463 (69.3)	528 (70.1)	693 (60.3)	342 (59.5)	351 (61.0)
Hyperlipidaemia**	473 (28.3)	229 (35.3)	243 (32.6)	330 (28.7)	164 (28.5)	166 (28.9)
Diabetes mellitus††	327 (19.6)	147 (22.7)	180 (23.6)	216 (18.8)	104 (18.1)	112 (19.5)
Ischemic stroke or TIA‡‡	300 (17.9)	175 (26.4)	125 (16.7)	207 (18.0)	106 (18.4)	101 (17.6)
Coronary heart disease§§	211 (12.6)	109 (16.9)	102 (13.2)	135 (11.7)	69 (12.0)	66 (11.5)
Stroke causative mechanism‖‖						
Large artery atherosclerosis	652 (39.0)	230 (35.7)	261 (34.7)	454 (39.5)	225 (39.1)	229 (39.8)
Cardioembolism	658 (39.4)	243 (37.7)	300 (39.9)	436 (37.9)	216 (37.6)	220 (38.3)
Other or known	362 (21.7)	171 (26.6)	191 (25.4)	260 (22.6)	134 (23.3)	126 (21.9)
Occlusion sites						
Proximal BA	549 (32.8)	255 (32.9)	294 (32.8)	373 (32.4)	182 (31.7)	191 (33.2)
Middle BA	540 (32.3)	253 (32.6)	287 (32.0)	377 (32.8)	192 (33.4)	185 (32.2)
Distal BA	583 (34.9)	268 (34.5)	315 (35.2)	400 (34.8)	201 (34.9)	199 (34.6)
Treatment profiles						
Intravenous thrombolysis	404 (24.2)	197 (25.4)	207 (23.1)	277 (24.1)	136 (23.7)	141 (24.5)
Stroke onset to puncture (min)	443 (320–694)	435 (322–677)	448 (318–705)	441 (320–687)	446 (322–685)	433 (316–693)
Stroke onset to reperfusion (min)	535 (407–793)	540 (415–776)	531 (400–800)	531 (404–781)	536 (406–778)	528 (401–793)
Type of endovascular treatment						
Stent retriever thrombectomy	1,095 (65.5)	551 (71.7)	544 (60.2)	788 (68.5)	388 (67.5)	400 (69.6)
Aspiration	319 (19.1)	96 (12.5)	223 (24.7)	180 (15.7)	91 (15.8)	89 (15.5)
Balloon angioplasty and/or stenting	252 (15.1)	118 (15.3)	134 (14.8)	177 (15.4)	93 (16.2)	84 (14.6)
Intra-arterial thrombolysis	6 (0.4)	4 (0.5)	2 (0.2)	5 (0.4)	3 (0.5)	2 (0.4)

Data are presented as median (interquartile range) or n (%).
PSM, propensity score matching; GA, general anesthesia; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; ASITN/SIR, the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology collateral score; NIHSS, National Institutes of Health Stroke Scale; GCS, Glasgow Coma Scale; TIA, transient ischemic attack; BA, basilar artery.
*215 missing values; †281 missing values; ‡316 missing values; §93 missing values; ‖265 missing values; ¶251 missing values; **278 missing values; ††260 missing values; ‡‡259 missing values; §§252 missing values; ‖‖276 missing values.

https://doi.org/10.5853/jos.2023.00318

Results

Patient characteristics

From March 2017 to February 2021, 1,672 patients with BAO who underwent EVT across 48 sites were included in the ATTENTION registry. Among them, GA was used in 769 patients (46.0%), and non-GA was used in 903 patients (54.0%). Ninety-four patients (5.6%) converted from non-GA to GA during EVT. Of the patients who received non-GA, 688 (41.2%) received LA and 215 (12.9%) received CS. Overall, the median age of patients was 66 years old (IQR, 56 to 73), and the median baseline NIHSS score was 20 (IQR, 13–29). The median time from the estimated time of BAO to artery puncture was 443 minutes (IQR, 320–694). The level of BAO site was proximal basilar (32.8%), mid–basilar (32.3%), and distal basilar artery (34.9%). The rate of utilization of GA versus non-GA was similar in patients with BAO secondary to large artery atherosclerosis (35.7% vs. 34.7%) and cardioembolism (37.7% vs. 39.9%). The proportion of GA for all BAO patients who received EVT varied from 23% to 69% in each center.

Table 1 presents the baseline patient characteristics according to anesthetic management received after handling missing values by multiple imputations before and after PSM. Balance diagnostics before and after PSM and IPTW are presented in Supplementary Table 1. After PSM,1,150 patients remained in the analysis, with all variables having a standardized difference of less than 10%.

Clinical outcomes

The results of the adjusted analyses using the overall cohort, the PSM-based cohort, and the IPTW-based cohort are summarized

Table 2. Adjusted association of clinical and safety outcomes with anesthetic management from patients in the ATTENTION registry

	Unmatched		PSM-based analysis		IPTW-based analysis	
	Adjusted value (95% CI)	*P*	Adjusted value (95% CI)	*P*	Adjusted value (95% CI)	*P*
Clinical outcomes						
mRS at 90 days*	1.11 (0.93, 1.33)	0.25	1.01 (0.82, 1.25)	0.91	1.45 (1.20, 1.75)	<0.01
mRS 0–3 at 90 days†	1.05 (0.96, 1.15)	0.28	1.00 (0.88, 1.14)	0.99	1.05 (0.94, 1.18)	0.35
mRS 0–2 at 90 days†	1.02 (0.92, 1.13)	0.72	0.93 (0.80, 1.09)	0.39	1.02 (0.90, 1.16)	0.75
mRS 0–1 at 90 days†	1.05 (0.92, 1.20)	0.49	0.93 (0.76, 1.15)	0.52	1.05 (0.89, 1.26)	0.55
NIHSS score at 24 hrs‡	0.56 (-0.78, 1.91)	0.41	1.31 (-0.27, 2.89)	0.11	0.55 (-0.79, 1.88)	0.42
NIHSS score at 5–7 days or discharge‡	-1.10 (-2.47, 0.28)	0.12	-0.50 (-2.04, 1.04)	0.52	-1.04 (-2.40, 0.32)	0.13
Reperfusion grade (mTICI) 2b-3†	1.01 (0.98, 1.04)	0.65	0.98 (0.94, 1.02)	0.35	1.01 (0.98, 1.05)	0.54
Safety outcomes						
Mortality at 90 days†	0.93 (0.84, 1.04)	0.19	0.95 (0.83, 1.08)	0.44	0.93 (0.83, 1.05)	0.24
sICH at 3 days†	1.07 (0.69, 1.68)	0.76	0.89 (0.54, 1.48)	0.66	1.05 (0.69, 1.61)	0.82

Estimates were adjusted for age, baseline NIHSS, level of occlusion sites, pc-ASPECTS score, GCS score, centre preference for GA, intravenous thrombolysis, history of atrial fibrillation and diabetes mellitus.

ATTENTION, Endovascular Treatment for Acute Basilar Artery Occlusion; PSM, propensity score matching; IPTW, inverse probability of treatment weighting; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; mTICI, modified Thrombolysis in Cerebral Infarction; sICH, symptomatic intracranial hemorrhage; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; GCS, Glasgow Coma Scale; GA, general anesthesia.

*The effect measure was expressed as a common odds ratio; †The effect measure was expressed as a rate ratio or risk ratio; ‡The effect measure was expressed as a mean difference.

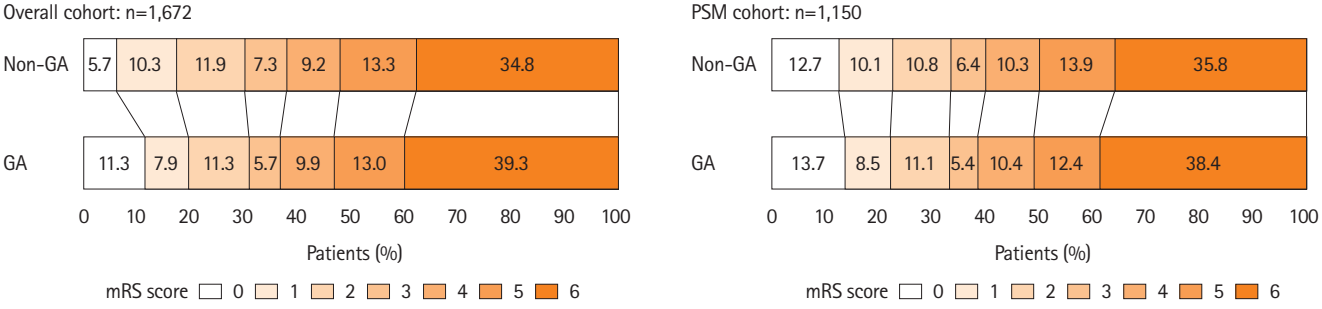

Figure 1. Distribution of the mRS score in patients who received non-GA vs. GA. mRS, modified Rankin Scale; GA, general anesthesia; PSM, propensity score matched.

in Table 2. The distribution of the 90-day mRS scores according to anesthetic modality before and after PSM is shown in Figure 1. In the unmatched cohort, the 3-month median mRS score was 5 (IQR, 2–6) in the GA group versus 4 (IQR, 2–6) in the non-GA group. The main analysis of the primary outcome in the PSM cohort showed no significant difference between the GA and non-GA groups (adjusted common odds ratio [acOR], 1.01 [95% CI, 0.82–1.25]; *P*=0.91). The proportion of patients achieving good functional outcomes also showed no significant difference between the GA and non-GA groups (adjusted rate ratio: 1.00 [95% CI: 0.88 to 1.14]). In our secondary analyses using the IPTW regression adjustment model, the anesthetic modality was significantly associated with the distribution of mRS at 90 days (acOR: 1.45 [95% CI: 1.20 to 1.75]; *P*<0.01) (Table 2). There was no difference in successful reperfusion between the GA versus non-GA groups (Table 2).

In the PSM cohort, the NIHSS score at 24 hours and 5 to 7 days were similar between the GA and non-GA group (NIHSS score at 24 hours: adjusted mean difference, 1.31 [95% CI: -0.27 to 2.89; NIHSS score at 5 to 7 days: adjusted mean difference, -0.50 [95% CI: -2.04 to 1.04]). A similar association was seen in the IPTW cohort.

Safety outcomes

In the PSM cohort, the 90-day mortality was similar between patients who received non-GA and those who received GA (adjusted risk ratio: 0.95 [95% CI: 0.83 to 1.08]; *P*=0.44). The crude probability of sICH at 3 days was 4.4% in patients who received GA and 5.4% in those who received non-GA (adjusted risk ratio: 0.89 [95% CI: 0.54 to 1.48]). A similar association was seen in the IPTW cohort.

Subgroup analysis

The relation between the occurrence of the distribution of mRS at 90 days and anesthetic management was consistent across subgroups, except for the history of AF, in which a significant interaction was observed (Figure 2). The adjusted difference in the distribution of mRS at 90 days between GA and non-GA was

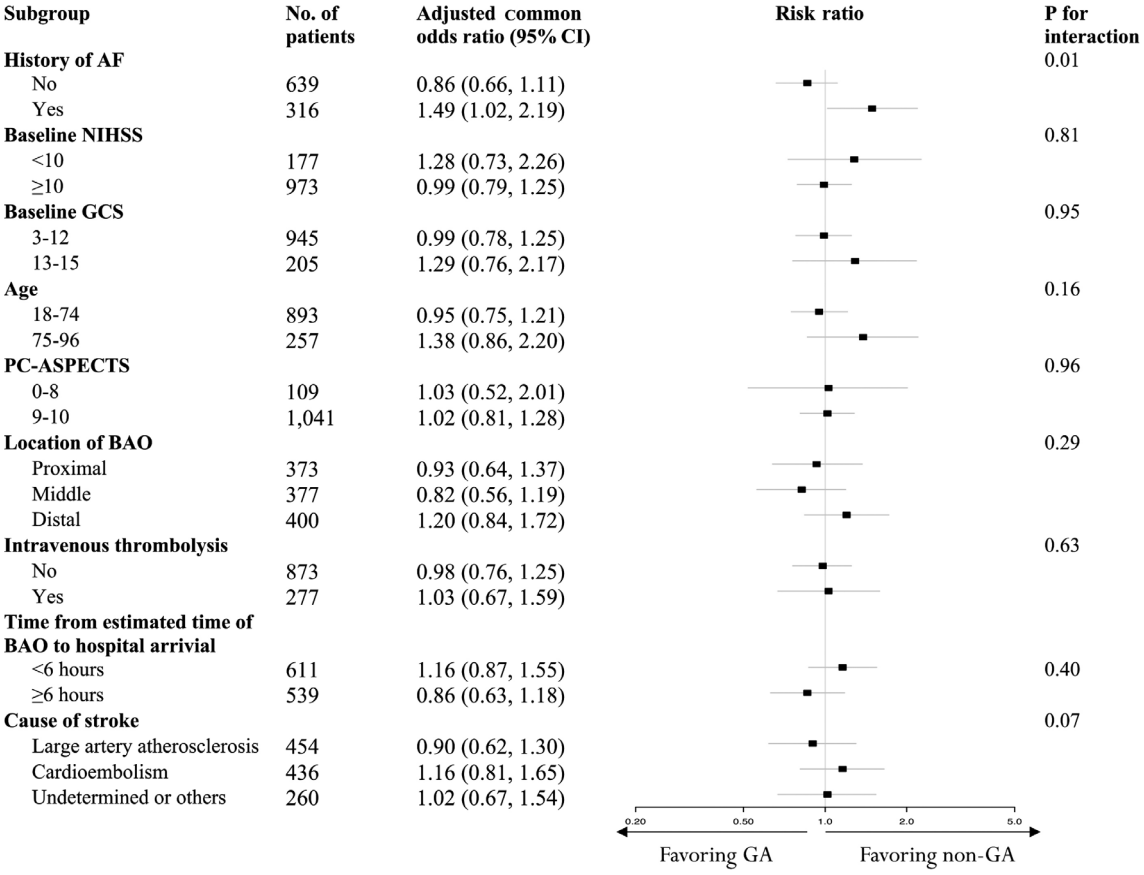

Figure 2. Subgroup analyses in patients of the ATTENTION BAO registry undergoing GA vs. non-GA in the PSM cohort. A forest plot shows the difference in the primary clinical outcome (adjusted common odds ratio indicating the odds of improvement of one point on the modified Rankin Scale at 90 days toward better outcome, analyzed using ordinal logistic regression) between GA and non-GA group. GA, general anesthesia; PSM, propensity score matched; CI, confidence interval; AF, atrial fibrillation; NIHSS, National Institutes of Health Stroke Scale; GCS, Glasgow Coma Scale; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; ATTENTION, Endovascular Treatment for Acute Basilar Artery Occlusion; BAO, basilar artery occlusion.

https://doi.org/10.5853/jos.2023.00318

greater in patients with a history of AF (acOR: 1.49 [95% CI: 1.02 to 2.19]) as compared to patients without a history of AF (acOR: 0.86 [95% CI: 0.66 to 1.11]; *P* for heterogeneity, 0.01).

Clinical and safety outcomes in ATTENTION RCT

We replicated these findings in patients assigned to the EVT group and receiving corresponding therapy from the ATTENTION RCT trial. Supplementary Table 2 presents the baseline patient characteristics according to anesthetic management received. The clinical and safety outcomes were similar between patients who received GA and non-GA with the same covariate adjustment (Table 3).

Discussion

The findings from this national stroke registry provide real-world evidence related to the anesthetic modality during EVT for patients with BAO. In the present study of 1,672 patients, we did not observe an association between anesthesia modality and clinical and safety outcomes in the PSM and IPTW-based cohort. To further test the results, we analyzed the association between anesthetic modality and clinical outcomes in patients who received EVT from the ATTENTION RCT. This also confirmed the lack of an association between anesthetic modality and the clinical and safety outcomes in BAO patients who underwent EVT. Therefore, non-GA is feasible and appears to be associated with similar clinical and safety outcomes compared to patients treated with GA.

The optimal anesthetic modality for patients with BAO during EVT remains uncertain. Several observational studies compared the clinical outcomes between non-GA and GA during EVT in patients with large vessel occlusion in the anterior circulation. These studies and the HERMES (Highly Effective Reperfusion Evaluated in Multiple Endovascular Stroke Trials) meta-analysis showed better functional outcomes in patients receiving non-GA.[3,5,32-35] However, the randomized controlled trials have shown comparable or even worse outcomes in patients receiving non-GA.[11,13] In addition, a few observational studies investigated whether different anesthesia modality affects outcomes in patients with BAO. Similar to the studies of large vessel occlusion in the anterior circulation, these studies also suggested comparable or better functional outcomes in patients receiving non-GA.[15-17,19]

In this study, non-GA patients had a comparable 90-day mRS to those who received GA. In addition, the null association between anesthetic management and clinical outcomes from patients who received EVT in the ATTENTION RCT trial served as adjunctive support for our findings. In line with our results, the BASILAR (Endovascular Treatment for Acute Basilar Artery Occlusion Study) registry, ETIS (Endovascular Treatment in Ischemic Stroke) registry, and CANVAS II (Choice of Anesthesia for Endovascular Treatment of Acute Ischemic Stroke) trial all suggested that the choice of anesthetic strategy did not affect the clinical outcomes of patients with BAO undergoing thrombectomy.[16,17,23]

In the ATTENTION registry, we noted that the baseline NIHSS

Table 3. Adjusted association of clinical and safety outcomes with anesthetic management from patients in the ATTENTION RCT

	Unmatched		Adjusted analysis	
	GA (n=124)	Non-GA (n=99)	Adjusted value (95% CI)	*P*
Efficacy outcomes				
mRS at 90 days, median (IQR)*	4.5 (2–6)	4 (2–6)	1.11 (0.53–2.33)	0.78
mRS 0–3 at 90 days, n (%)†	57 (46.0)	46 (46.5)	0.90 (0.37–2.21)	0.82
mRS 0–2 at 90 days, n (%)†	39 (31.5)	35 (35.4)	1.03 (0.40–2.64)	0.95
mRS 0–1 at 90 days, n (%)†	26 (21.0)	18 (18.2)	0.77 (0.25–2.39)	0.65
NIHSS score at 24 hrs, median (IQR)‡	23 (9–37)	17 (5–37)	-1.95 (-7.00–3.09)	0.45
NIHSS score at 5–7 days or discharge, median (IQR)‡	19 (6–35)	13 (3–35)	-1.39 (-7.57–4.8)	0.66
Reperfusion grade (mTICI) 2b-3, n (%)†	115 (92.7)	93 (94.0)	0.77 (0.15–3.94)	0.75
Safety outcomes				
Mortality at 90 days, n (%)†	49 (39.5)	33 (33.3)	0.73 (0.30–1.79)	0.49
sICH at 3 days, n (%)†	5 (4.5)	7 (7.7)	1.17 (0.19–7.27)	0.86

Estimates were adjusted for age, baseline NIHSS, level of occlusion site, pc-ASPECTS score, GCS score, centre preference for GA, intravenous thrombolysis, history of atrial fibrillation and diabetes mellitus.
ATTENTION, Endovascular Treatment for Acute Basilar Artery Occlusion; RCT, randomized controlled trial; GA, general anesthesia; mRS, modified Rankin Scale; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale; mTICI, modified Thrombolysis in Cerebral Infarction; sICH, symptomatic intracranial hemorrhage; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; GCS, Glasgow Coma Scale.
*The effect measure was expressed as a common odds ratio; †The effect measure was expressed as a risk ratio; ‡The effect measure was expressed as a mean difference.

score and GCS score did not differ significantly between the two groups (GA vs. non-GA: NIHSS 22 vs. 20; GCS 7 vs. 8), which suggested that the choice of anesthesia modality did not rely on the severity of the patient's clinical presentation, but more likely based on the preference of each center and each physician. As there was no significant difference in baseline NIHSS and GCS scores, our results are more likely to reflect the effect of anesthesia modality on the outcomes of BAO patients who underwent EVT. Alternatively, it is possible that other patient or airway-specific factors (i.e., patient level of consciousness, emesis, patient agitation, or patient COVID-19 status), which the total NIHSS and GCS may not capture, may have played a role in the decision of pursuing GA versus non-GA.[36]

Previous randomized controlled studies showed that patients receiving GA have higher chances of mTICI 2b-3 than patients receiving local anesthesia,[11,13] which may have contributed to better clinical outcomes in patients receiving general anesthesia. However, our trial demonstrated a similar reperfusion grade between the two groups, hence the comparable clinical outcomes between patients who received GA and non-GA.

Our study has demonstrated that patients with AF who received non-GA had better clinical outcomes than those who received GA. One possible explanation for this finding could be that timely reperfusion for patients with AF may be more crucial than for those without AF. This is because patients with intracranial atherosclerosis (ICAS) may have already suffered from a significant period of blood insufficiency. In contrast, for patients with AF, collateral circulation may not have developed as much as it has for those with ICAS. However, despite our assumptions, a clear explanation for this finding based on our data could not be established. Further studies are needed to explore potential factors that may contribute to this result.

Our results showed that non-GA might be a preferred choice for the anesthetic management of BAO patients during EVT because of the comparable or possibly better functional outcomes after non-GA. In addition, non-GA may not require the presence of an anesthesiologist, which in many cases may facilitate earlier arterial puncture. Non-GA is also conducive to the timely detection of changes in the patient's condition during the procedure and the evaluation of the patient's level of consciousness post-procedure.

The results of this study should be interpreted in light of several limitations. First and most importantly, this was a non-randomized comparison that posed a selection bias risk. The choice of anesthesia was largely based on the anesthetic strategy of each center or the preference of the neurointerventionalist. However, it should be noted that a considerable number of patients may receive general anesthesia due to factors such as airway protection, severe agitation, or other factors that were not collected in our study. Despite that, we used propensity score analysis and IPTW to minimize the differences in baseline characteristics. Our results could be confounded by variables not included in the propensity model. Second, all outcomes were assessed unblind by local investigators. Another major limitation of this study was that we did not collect information on specific types of anesthetic agents used and hemodynamic fluctuations during thrombectomy.

Conclusions

In this large observational, registry-based study, we found preliminary evidence that non-GA was comparable to GA with respect to the functional and safety outcomes in patients with BAO who underwent EVT. Future randomized controlled trials are needed to determine the best anesthetic modality for patients with acute BAO undergoing EVT.

Supplementary materials

Supplementary materials related to this article can be found online at https://doi.org/10.5853/jos.2023.00318.

Funding statement

This study was funded by the Fundamental Research Funds for the Central Universities (no. YD9110002014), China Postdoctoral Science Foundation (no. 2021M703087) and the National Natural Science Foundation of China (no. 82201490).

Conflicts of interest

The authors have no financial conflicts of interest.

Author contribution

Conceptualization: WH, QL. Study design: WH, QL. Data collection: CT, GY, PX, HW, PZ, TY, KL, TC, JG, RL, JS, CZ, LW, TL, JS, YY. Statistical analysis: CT, WH, TNN, QL. Writing—original draft: CT. Writing—review & editing: all authros. Approval of final manuscript: all authors.

Acknowledgments

We thank staff and participants in the ATTENTION Registry for their contribution to the collection of data.

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https://doi.org/10.5853/jos.2023.00318

Supplementary Table 1. Standardized difference of baseline characteristics according to general anesthesia or non-general anesthesia before and after PSM and IPTW

	Overall cohort	PSM cohort	IPTW cohort
Age	10.5	-2.2	-0.5
Sex	7.5	-4.4	-0.2
Baseline pc-ASPECTS	-11.2	-7.1	0.5
ASITN/SIR grade	1.3	-2.7	0.7
Systolic blood pressure on admission	-12.5	8.7	0.3
Diastolic blood pressure on admission	-9.0	6.1	0.1
Baseline NIHSS score	-13.1	3.5	-0.3
Baseline GCS score	18.9	2.9	-1.0
Medical history			
Atrial fibrillation	-4.6	-2.2	0.3
Hypertension	6.3	1.1	-0.9
Hyperlipidaemia	-4.8	-1.5	0.3
Diabetes mellitus	6.6	0.7	-1.0
Ischemic stroke or TIA	-14.2	4.2	-0.2
Coronary heart disease	-11.1	0.5	-0.1
Stroke causative mechanism	-0.7	-4.2	0.1
Occlusion sites	-3.6	1.4	-0.3
Treatment profiles			
Intravenous thrombolysis	-5.1	-4.2	-1.1
Stroke onset to puncture	1.5	-1.9	0.1
Stroke onset to reperfusion	-3.3	-1.7	0.1

PSM, propensity score matching; IPTW, inverse probability of treatment weighting; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; ASITN/SIR, the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology collateral score; NIHSS, National Institutes of Health Stroke Scale; GCS, Glasgow Coma Scale; TIA, transient ischemic attack.

Supplementary Table 2. Baseline characteristics according to general anesthesia or non-general anesthesia in the ATTENTION RCT cohort

	All (n=222)	GA (n=123)	Non-GA (n=99)
Age, median (IQR)	67 (57–75)	67 (57–74)	68 (58–74)
Sex			
Female	148 (66.7)	87 (70.7)	61 (61.6)
Male	74 (33.3)	36 (29.3)	38 (38.4)
Baseline pc-ASPECTS			
≥8	177 (79.7)	93 (75.6)	84 (84.9)
Blood pressure on admission (mm Hg), median (IQR)			
Systolic	150 (134–168)	155 (135–169)	143 (132–163)
Diastolic	85 (77–95)	85 (76–97)	85 (78–95)
Baseline NIHSS score, median (IQR)	25 (15–35)	25 (15–35)	24 (16–35)
Baseline GCS score, median (IQR)	8 (6–12)	8 (6–12)	8 (6–12)
Medical history			
Atrial fibrillation	45 (20.3)	21 (17.1)	24 (24.2)
Hypertension	159 (71.6)	95 (77.2)	64 (64.7)
Hyperlipidaemia	59 (26.6)	28 (22.8)	31 (31.3)
Diabetes mellitus	47 (21.2)	47 (21.2)	20 (20.2)
Ischemic stroke or TIA	53 (23.9)	31 (25.2)	22 (22.2)
Coronary heart disease	35 (15.8)	22 (17.9)	13 (13.1)
Stroke causative mechanism			
Large artery atherosclerosis	106 (47.8)	64 (52)	42 (42.4)
Cardioembolism	46 (20.7)	19 (15.5)	27 (27.3)
Other or known	70 (31.5)	40 (32.5)	30 (30.3)
Occlusion sites			
V4	20 (9.0)	8 (6.5)	12 (12.1)
Proximal BA	69 (31.1)	42 (34.2)	27 (27.3)
Middle BA	60 (27)	34 (27.6)	26 (26.3)
Distal BA	73 (32.9)	39 (31.7)	34 (34.3)
Treatment profiles			
Intravenous thrombolysis	68 (30.6)	33 (26.8)	35 (35.4)
Stroke onset to puncture (hr), median IQR	5.6 (3.5–6.5)	5.6 (3.6–7.8)	5.5 (3.5–7.2)
Stroke onset to reperfusion (hr), median IQR	7.0 (5.0–8.8)	7.3 (5.3–9.2)	6.7 (4.6–8.6)

Data are presentend as n (%) unless otherwise indicated.
ATTENTION, Endovascular Treatment for Acute Basilar Artery Occlusion; RCT, randomized controlled trial; GA, general anesthesia; IQR, interquartile range; pc-ASPECTS, posterior circulation Acute Stroke Prognosis Early Computed Tomography Score; NIHSS, National Institutes of Health Stroke Scale; GCS, Glasgow Coma Scale; BA, basilar artery.

https://doi.org/10.5853/jos.2023.00318