Original research

Incidence of intracranial hemorrhagic complications after anterior circulation endovascular thrombectomy in relation to occlusion site: a nationwide observational register study

Emma Hall ,[1,2] Teresa Ullberg ,[1,3] Gunnar Andsberg,[1,3] Johan Wasselius [1,2]

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[1]Department of Clinical Science, Lund University Faculty of Medicine, Lund, Sweden
[2]Department of Medical Imaging and Physiology, Skåne University Hospital Lund, Lund, Sweden
[3]Department of Neurology, Skåne University Hospital Lund, Lund, Sweden

Correspondence to
Dr Johan Wasselius; johan.wasselius@gmail.com

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ABSTRACT

Background Intracranial hemorrhage (ICH) is a potentially severe complication of endovascular thrombectomy (EVT). However, the relationship between the incidence and severity of ICH and vascular occlusion location is not well described.

Objective To present a comprehensive analysis of subtypes of ICHs and their relationship to the occlusion site following EVT in the anterior circulation.

Methods All patients with anterior circulation vessel occlusion stroke (internal carotid (ICA) and middle cerebral artery's first (M1) and later segments (M2 and beyond)) registered in the two Swedish national quality registers for stroke care and endovascular therapy during 2015–2020 were included. Hemorrhagic complications identified on imaging within 36 hours post-EVT were classified according to Heidelberg Bleeding Classification and further divided into symptomatic (sICH) or non-symptomatic (non-sICH).

Results Of the 3077 patients, ICH frequency was 24.2%, which included 4.5% sICH. Subarachnoid hemorrhage (SAH) was the most frequent subtype of hemorrhage (10.9%). The hemorrhagic subtypes differed significantly by occlusion site, but the frequency of any bleed did not. EVT performed in and beyond the M2 more often resulted in SAH, frequently classified as non-sICH. EVT performed in the ICA was associated with more severe hemorrhages, such as intraventricular and large parenchymal hematomas, that were more often classified as sICH.

Conclusion In this nationwide unselected EVT cohort we found that ICH severity significantly differed between different vessel occlusion sites.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Symptomatic hemorrhages and large parenchymal hematomas following endovascular thrombectomy (EVT) are associated with poor functional outcome.

WHAT THIS STUDY ADDS

⇒ This study reveals differences in post-EVT hemorrhage characteristics between vessel occlusion locations. It also shows that EVT in proximal vessels is associated with higher incidence of symptomatic bleedings and that EVT in distal vessels result in a higher incidence of subarachnoid hemorrhages and lower incidence of symptomatic bleedings.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The results suggests that the vessel occlusion site can be used to estimate the risk of post-EVT intracranial hemorrhages. Furthermore, the risk of symptomatic intracranial hemorrhage should not limit the use of EVT in distal vessels.

INTRODUCTION

Endovascular thrombectomy (EVT) is the standard of care for acute ischemic stroke (AIS) caused by large vessel occlusions and has been implemented on a global scale during the last decade. Recent clinical trials have proved the safety and efficacy of EVT up to 24 hours following AIS.[1–3] Additionally, recent randomized trials demonstrated significantly improved functional outcomes of EVT treatment compared with best medical care alone in patients with large ischemic infarctions at presentation, despite higher incidences of intracranial hemorrhage (ICH).[4]

However, EVT treatment is associated with procedural and postprocedural complications, such as distal embolization, vessel perforation, dissection, and ICH.[5] Hemorrhagic complications related to EVT range from small petechial hemorrhagic infarcts (HI1 and HI2), brain parenchymal hematomas (PH1 and PH2), brain parenchymal hematomas remote to the infarct (PHr), intraventricular hemorrhage (IVH), subarachnoid hemorrhage (SAH), and subdural hemorrhage (SDH). The underlying causes of hemorrhagic transformation include procedural vascular trauma, reperfusion bleedings during the restoration of cerebral blood flow to infarcted brain tissue, and failed recanalization.[1 5 6]

The Heidelberg Bleeding Classification (HBC) is commonly used to reflect the heterogeneity in presentation and prognosis between various post-EVT ICH types.[7] Hemorrhagic complications following EVT are also commonly divided into non-symptomatic (non-sICH) or symptomatic (sICH), based on the clinical effect of the bleeding. It is generally believed that non-sICH has little or

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no impact on functional outcome,[8 9] whereas sICH is associated with poor functional outcome or death.[10]

Previous studies have shown that the frequency of sICH following EVT varies between 3.6% and 9.3%[5] and that stent retrievers combined with aspiration thrombectomy as first-line strategy results in lower frequency of sICH but a higher frequency of SAH after EVT in distal and medium vessel occlusions[11] and a higher first-pass efficacy without an increase of hemorrhagic complications in carotid terminus thrombectomy.[12] However, knowledge about the prevalence of sICH and whether ICH subtypes differ between occlusion sites is limited. Using data from two national Swedish stroke databases with >90% coverage of EVT procedures, this study aims to explore the incidence of symptomatic hemorrhagic complications by occlusion location and HBC classification in an unselected EVT population between 2015 and 2020.

METHODS

Study design

We conducted a nationwide observational study based on data from the Swedish Endovascular Treatment of Acute Stroke (EVAS) Registry and the Swedish Stroke Register (Riksstroke). Patients were included in the analysis if they had been treated endovascularly by thrombectomy due to occlusion in the anterior circulation between 2015 and 2020 and were registered in both EVAS and Riksstroke.

Data sources

The Swedish Endovascular Treatment of Stroke Register and the Swedish Stroke Register

The EVAS Register is the Swedish national quality register for endovascular treatment of acute ischemic stroke used at all six Swedish stroke centers.[13] It collects comprehensive data on procedural details, complications, clinical variables, and functional outcome. Riksstroke is the Swedish quality register for general stroke care,[14] gathering data from all 72 Swedish hospitals managing acute stroke care. It includes information on clinical aspects, such as risk factors, pre-stroke and post-stroke functional status and mortality. Both registers consistently achieve over 90% coverage for EVTs performed in Sweden.

Main variables

Intracranial occlusions were defined by their proximal end. I-type and T-type internal carotid artery (ICA) occlusions were categorized as ICA occlusions, and occlusions in the middle cerebral artery (MCA) were categorized either as M1, or M2 and beyond. All hemorrhagic complications were systematically categorized according to the HBC[7] based on follow-up with a non-contrast computed tomography scan conducted 24 hours after the EVT procedure or within 4–36 hours in cases of clinical deterioration.

Hemorrhages occurring 4–36 hours following EVT were classified as sICH if they fulfilled one of the following criteria: (1) registered as sICH in Riksstroke or (2) resulted in a minimum 4-point increase in the National Institutes of Health Stroke Scale (NIHSS) or death within 7 days. Cases involving concomitant malignant media infarction, unrelated cause of death, or severe comorbidities, were designated as uncategorized ICH owing to the challenge in determining whether the neurological deterioration was solely attributed to the ICH. Hemorrhagic complications with a maximum NIHSS increase of 3 points, were classified as non-sICH.

Cases with more than one subtype of hemorrhage were classified as the most severe subtype, defined by a higher HBC number. The only exception was for intraventricular hemorrhages, where independent bleedings and bleedings as an extension of other types of hemorrhages were grouped together. Solitary subarachnoid bleeding was classified as SAH, whereas subarachnoid hemorrhage in combination with parenchymal bleedings was classified as the most severe parenchymal type.

The Alberta Stroke Program Early CT Score (ASPECTS) is a 10-point quantitative scoring system based on the presence of ischemic damage within defined regions of the MCA territory.[15] In our study, the extent of infarction was divided into four modified ASPECT groups based on the available infarct classification in the EVAS register: (1) ASPECTS 10 (no ischemic injury); (2) ASPECTS 7–9 (infarct less than 1/3 of the MCA territory or infarct in the basal ganglia); (3) ASPECTS 5–6 (infarct less than 1/3 of the MCA territory and infarct in the basal ganglia); and (4) ASPECTS 0–4 (infarct more than 1/3 of the MCA territory), where lower scores indicate larger quantity of established injury.

Statistical analysis

IBM SPSS Statistics version 28 was used for statistical analysis. Baseline data were presented as medians with IQR or simple proportions. A p-value (two-sided) <0.05 was considered statistically significant. Univariable logistic regression was used to explore the association between occluded vessel and the occurrence of sICH. Multivariable logistic regression was used to adjust the association between occlusion location and sICH with adjustment for potential confounders and included variables were sex, age, hypertension, diabetes, oral anticoagulant or vitamin K antagonist, single antiplatelet inhibition, double antiplatelet inhibition, NIHSS score, modified ASPECTS and intravenous thrombolysis. In the analysis, cases classified as uncategorized ICH were excluded from the overall study population. Two sensitivity analyses were conducted to control for the association between the vessel occlusion site and sICH. In the first sensitivity analysis, these cases were included in the sICH group, and in the second sensitivity analysis, they were included in the non-sICH group.

RESULTS

During 2015–2020, 3340 EVT treatments in the anterior circulation were registered in both EVAS and Riksstroke. Cases with resolved embolus or inaccessible occlusion site (n=154) were excluded. Isolated anterior cerebral artery occlusions were rare (n=33) and therefore not included in the analysis. sICH data were available for 93.6% of the population with ICH within 4–36 hours after EVT for ICA or MCA occlusions (n=3153). Out of the remaining 6.4% (n=203) without sICH data, 158 cases met the criteria for non-sICH, 39 cases met the second criteria for sICH, and 6 cases were labeled as uncategorized ICH due to concomitant malign media infarct, sepsis, or liver failure leading to death. Additionally, 70 cases with available sICH data and an increase in NIHSS score with a minimum of 4 points or death within 7 days, were labeled as uncategorized ICH due to concomitant severe complications causing difficulties determining the cause of clinical deterioration. The hemorrhages classified as uncategorized ICH were excluded from the analysis (n=76). Figure 1 illustrates the final study population.

Table 1 presents the baseline demographics and procedural characteristics of the 3077 patients in the final study population. Median age was 74 years (IQR 66–82), with 50.3% being female. There were 609 (19.8%) ICA occlusions, 1710 (55.6%) M1 occlusions, and 758 (24.6%) occlusions in M2 and beyond. Patients with ICA

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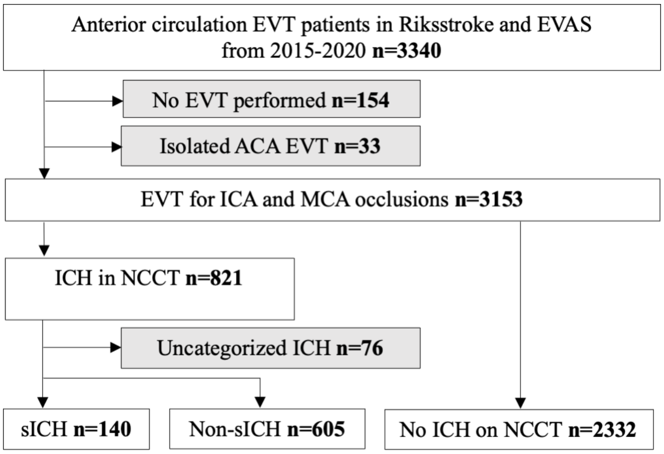

Figure 1 Flow chart illustrating the study population (n=3077). ACA, anterior cerebral artery; EVT, endovascular thrombectomy; ICA, internal carotid artery; MCA, middle cerebral artery; NCCT, non-contrast CT; sICH, symptomatic intracranial hemorrhage.

occlusion presented with slightly lower ASPECT score, higher NIHSS score, were more often receiving dual antiplatelet therapy, and were more commonly treated using general anesthesia than cases involving M1 and M2/M3 segments. Antithrombotic treatment during the EVT procedure was most commonly administered for procedures in the ICA segment, while patients with distal occlusions had more commonly received IVT. A stent retriever was used alone or in combination with a distal aspiration catheter in 67.4%, and more commonly in distal vessels (73.5%) than in M1 (66.8%) and ICA (61.4%). EVT procedures targeting M1 exhibited a higher prevalence of successful revascularization (modified Thrombolysis in Cerebral Infarction score 2b–3) compared with both ICA and M2/M3. Throughout the observed period, a notable upward trend was observed in the frequency of EVTs, particularly for occlusions located within the M2 segment and beyond (figure 2B).

Incidence of hemorrhagic complications

The distribution of ICH subtypes as well as sICH/non-sICH in relation to occlusion site is shown in figure 2C,D. The frequency of any post-EVT ICH for occlusions in and beyond the M2 was 25.3%, compared with 25% in M1 and 24.8% in ICA. The most common hemorrhagic subtype following EVT for ICA occlusions was HI2 (7.9%) followed by PH2 (4.4%). The most common hemorrhagic subtype following EVT for occlusions in the M1 and the M2 and beyond, was isolated SAH (7.8%, 12.4%), followed by HI2 (7.3%, 4.1%). The distribution of hemorrhagic subtypes are further described in online supplemental file 1 (figures 1 and 2).

Non-sICH was the dominating type of hemorrhagic complication for all occlusion sites. There was no significant difference in association between occlusion sites and any ICH or non-sICH (online supplemental table 1). IVH-type and PH2-type bleedings were commonly classified as sICH (online supplemental figures 2, 63.6% and 58.5% sICH, respectively) and was most frequent in the ICA group.

Association between vessel occlusion site and symptomatic hemorrhages in a univariable and multivariable regression analysis

The highest incidence of sICH was seen following EVT for ICA occlusions (6.4%), compared with M1 occlusions (4.2%) and occlusions in the M2 and beyond (4%). As illustrated in table 2, the difference was significant (OR=1.58, 95% CI 1.06 to 2.35) and the association did not change when being adjusted for potential confounders (OR=1.58, 95% CI 1.01 to 2.46). No significant difference was observed between occlusions in the M2 and beyond and M1 occlusions in the multivariable logistic regression analysis (OR=1.02, 95% CI 0.63 to 1.64).

DISCUSSION

The incidence of sICH in this nationwide unselected cohort undergoing EVT treatment for AIS was found to be (4.5%). This finding is in line with previous studies by Balami *et al*, who reported the incidence of sICH ranging between 3.6% and 9.3%, depending on the definition used.[5] Additionally, our study revealed differences in hemorrhage subtype frequency and significant differences in hemorrhage severity between occlusion sites.

M1 occlusions are the most common large vessels occlusions in clinical practice (55.6%) and were in this study associated with the lowest incidence of hemorrhagic complications in general, as well as the second lowest incidence of sICH. Although the overall hemorrhage frequency after EVT in the ICA was not higher than for distal occlusions, they were more likely to cause intraventricular hemorrhage and space-occupying intracerebral hemorrhages, thereby causing a significantly increased risk of sICH, which is in line with previous findings by Dong *et al*.[16] The differences in distribution of bleeding subtypes between the ICA, M1, and M2 and beyond groups may be explained by the variations in vascular supply between the affected brain areas, as well as by procedural aspects. ICA occlusions and proximal M1 occlusions often affect the lenticulostriate perforating arteries that have little collateral capacity, often causing basal ganglia infarctions.

In our study, we observed that patients with large infarct volume prior to EVT were relatively rare but more frequent in the ICA occlusion group, which is a logical consequence of the larger affected brain parenchyma and the scarcity of collateral vessels in the ICA territory. A recent meta-analysis conducted by Abuelazm *et al*[4] found an association between low ASPECTS and ICH but not between low ASPECTS and sICH. The findings indicate that the causal relationship between sICH and EVT procedure in the ICA is not solely determined by the larger affected brain area. Other factors are probably involved, and one potential contributing factor could be the wider lumen of the proximal vessels, facilitating a greater flow of blood to a larger volume of affected brain tissue.

Reperfusion of a large infarcted area[17] and elevated blood pressure following EVT have been associated with an increased risk of sICH and unfavorable functional outcome.[18] This represents a clinical challenge since a significant reperfusion flow is essential to restrain the transformation of penumbra to infarct. Furthermore, the ENCHANTED2/MT randomized controlled trial found that lowering blood pressure after successful recanalization resulted in worse functional outcome without reducing the risk of sICH.[19]

Recent trials have demonstrated favorable functional outcomes for EVT in patients with large ischemic infarctions at presentation,[3 20] but the risk of sICH after EVT in proximal vessels remains a crucial consideration. The management of blood pressure after an EVT procedure must be carefully approached, considering the delicate balance between achieving optimal reperfusion and minimizing the risk of adverse events, especially in cases involving proximal vessel occlusions.

Antithrombotic medication was most frequently administered during EVT for ICA occlusions. This treatment is often concomitant with intracranial adjunctive stenting, most commonly performed in the ICA. There is a concern that procedural

Table 1 Baseline and treatment characteristics in 3077 patients who underwent EVT for anterior circulation stroke caused by large or medium vessel occlusion

Demographics	All cases % (n=3077)	ICA 19.8% (n=609)	M1 55.6% (n=1710)	M2 and beyond 24.6% (n=758)
Age, years, (median (IQR)	74 (66–82)	73 (64–81)	74 (66–82)	75 (66–82)
Female sex	50.3 (1549)	48.8 (297)	53.2 (910)	45.1 (342)
Hypertension	60 (1846)	59.6 (363)	59.6 (1020)	61.1 (463)
Diabetes	17.4 (534)	17.2 (105)	16.4 (280)	19.7 (149)
Anticoagulant/antiplatelet drugs at admission				
VKA/OAC	17.9 (551)	18.1 (110)	17.5 (299)	18.7 (142)
SAPT	21.4 (660)	18.2 (111)	21.5 (367)	24 (182)
DAPT	1 (31)	1.3 (8)	1.1 (18)	0.7 (5)
Modified ASPECTS*				
10	45.5 (1399)	40.1 (244)	43.7 (747)	53.8 (408)
7–9	41 (1263)	40.2 (245)	42.3 (723)	38.9 (295)
5–6	5.4 (166)	8.5 (52)	6 (102)	1.6 (12)
<5	2.9 (88)	4.4 (27)	2.8 (48)	1.7 (13)
NIHSS score				
Pre-EVT,* median (IQR)	16 (11–20)	18 (15–21)	16 (12–20)	12 (7–17)
24 hours post-EVT,* median (IQR)	7 (2-14)	10 (4–17)	7 (2-15)	5 (1-11)
Type of anesthesia				
Conscious sedation	63.8 (1963)	59.3 (361)	63.5 (1086)	68.1 (516)
General	36 (1107)	40.6 (247)	36.2 (619)	31.8 (241)
Procedure strategy				
DAC	19.3 (594)	17.9 (109)	21.6 (370)	15.2 (115)
SR or SR+DAC	67.4 (2073)	61.4 (374)	66.8 (1142)	73.5 (557)
Angioplasty/stent	11.6 (357)	20 (122)	10.9 (187)	6.3 (48)
Other/not reported	1.7 (53)	0.7 (4)	0.6 (11)	5 (38)
Number of passes, median (IQR)	1 (1-3)	2 (1-3)	1 (1-3)	1 (1-2)
IVT treatment	48.2 (1484)	48.4 (295)	45.5 (778)	54.2 (411)
mTICI				
0–2a	14.1 (434)	15.1 (92)	12.9 (220)	16.1 (122)
2b–3	84.9 (2611)	83.9 (511)	86.1 (1472)	82.8 (628)
Antithrombotic treatment during procedure†				
Yes	22.4 (688)	28.4 (173)	21.5 (367)	19.5 (148)

*Missing data were ≤1% in all variables, except for NIHSS score before EVT (3.6%), NIHSS score after EVT (13.2%) and ASPECT score (5.2%).
†IV ASA/IV GPI inhibitors/IA thrombolysis/IV heparin.
ASA, acetylsalicylic acid; ASPECTS, Alberta Stroke Program Early CT Score; DAC, distal aspiration catheter; DAPT, double antiplatelet treatment; EVT, endovascular thrombectomy; GPI, glycoprotein I; IA, intra-arterial contrast medium ; ICA, internal carotid artery; IV, intravenous; IVT, intravenous thrombolysis; M1, M1-segment of middle cerebral artery; M2, M2-segment of middle cerebral artery; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; OAC, oral anticoagulant; SAPT, single antiplatelet treatment; SR, stent retriever; VKA, vitamin K antagonist.

antithrombotic medication would increase the risk of sICH. However, the recent CHOICE randomized clinical trial showed no increase in hemorrhagic complications in patients administered intra-arterial alteplase.[21]

Occlusions in M2 and beyond affect areas that usually have pial collateral supply, but where the procedural stretching of vessels might contribute to the higher proportion of SAH, as seen in this study. Advancements in procedural techniques and materials during the observed period have enabled EVT treatment in distal and smaller vessels and innovations like small-caliber catheters and low-profile stent retrievers have resulted in an increasing number of EVTs for occlusions in and beyond M2. The present study confirms that EVT performed in distal MCA segments is associated with a higher incidence of SAH. These hemorrhages are generally thought to have little effect on patient outcome. In our study, 12.8% of patients with occlusion in distal MCA vessels had post-EVT isolated SAHs, but the rate of sICH was 4% of all EVTs in M2 and beyond. The results implies that while the frequency of ICHs, and especially SAH, is higher after EVT in distal vessels, they are typically not associated with unfavorable functional outcome.

Earlier studies have shown a decreased incidence of ICHs,[10] and sICH[22] in patients with successful recanalization. However, a notable predominance of incomplete revascularization was observed within the M2 and beyond vessels, where the incidence of sICH was least pronounced. This observation suggests that the initial results concerning hemorrhagic complications following treatment of occlusions in the M2 and occlusions beyond M2

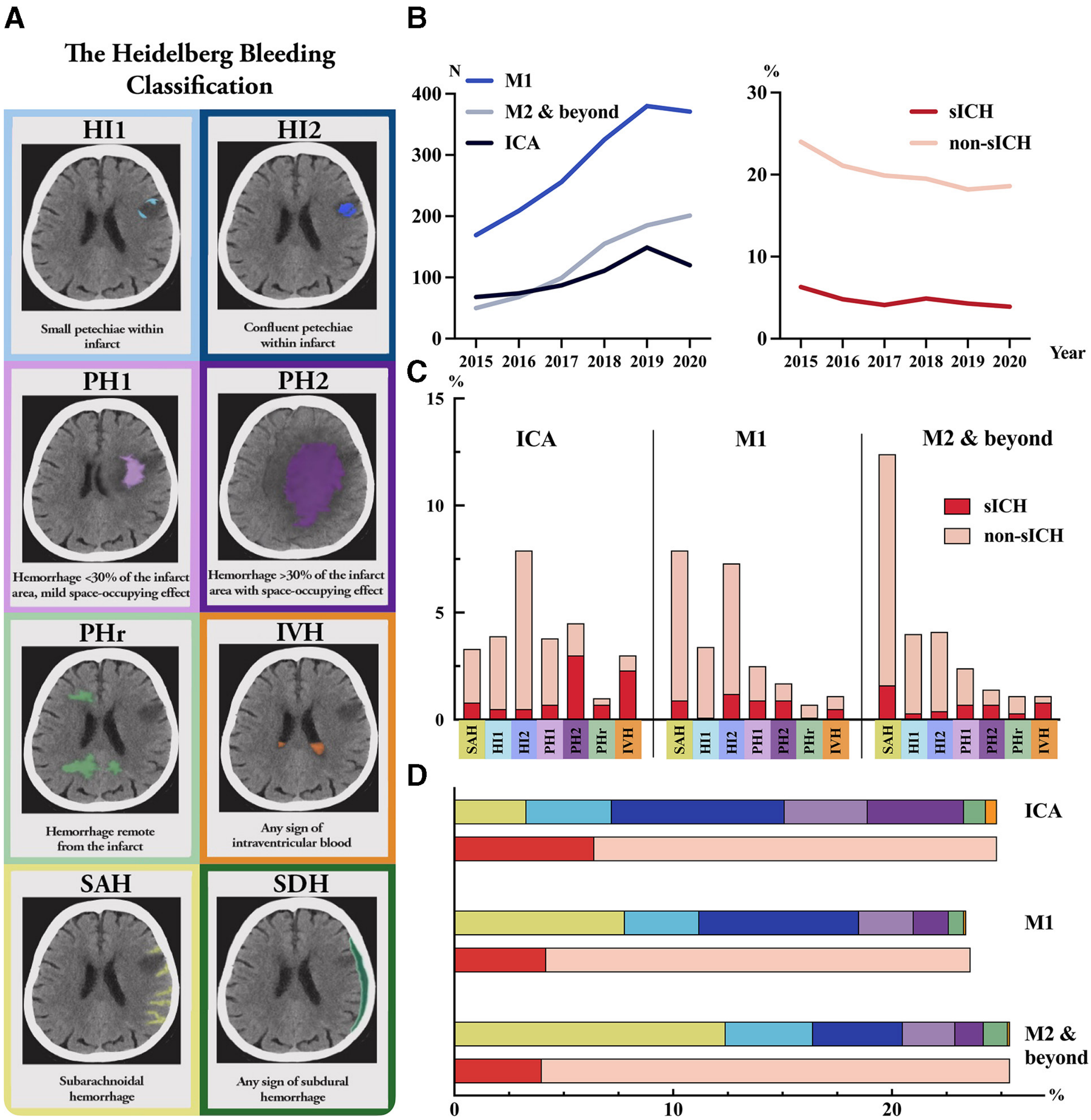

Figure 2 Incidence of hemorrhagic complications in relation to site of occlusion. (A) Illustration of hemorrhagic complications according to the Heidelberg Bleeding Classification. (B) Incidence of EVTs in relation to site of occlusion and the incidence of sICH and non-sICH during 2015–2020. (C) Incidence of hemorrhagic complications according to the HBC in relation to occlusion site, and the prevalence of sICH and non-sICH. (D) Overall incidence of sICH and non-sICH (color code B) and HBC subtypes (color code A) in relation to occlusion site. EVT, endovascular thrombectomy; HBC, Heidelberg Bleeding Classification; HI, hemorrhage infarcts; ICA, internal carotid artery; IVH, intraventricular hemorrhage; PH, parenchymal hematoma; PHr, parenchymal hematoma remote to the infarct; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage; sICH, symptomatic intracranial hemorrhage.

(illustrated in online supplemental figure 3) is promising. It also implies that there is still a potential for improvement in revascularization efficacy in the M2 and beyond vessels, and that the risk of sICH should not limit the use of EVT in the treatment of more distal vascular domains within the MCA territory.

Limitations

We acknowledge several limitations to our study. It should be noted that the definition of sICH in Riksstroke diverges from the Heidelberg Bleeding Classification, since sICH in Riksstroke does not include cases with 2-point deterioration within an isolated NIHSS category. Our ambition was to follow the Heidelberg Bleeding Classification, which led us to exclude cases with significant concurring causes of clinical deterioration. However, the precise identification of an isolated increase in points within an individual NIHSS category proved elusive since full-item NIHSS was first introduced in Riksstroke in 2020. Additionally, the categorization of sICH and δ-NIHSS were not complete in the registry. The frequency of sICH may be underestimated and could potentially be 6.9% (n=216) if all uncategorized ICHs were to be reclassified as sICH. The association between ICA occlusions and symptomatic hemorrhages remained unaltered in the conducted sensitively analyses (data not shown), irrespective of whether the uncategorized ICHs were included in the overall population (not as sICH) or were incorporated into the sICH group.

Second, the modified ASPECT score used in this study is an estimation, and the number of patients with low modified ASPECT score was relatively small.

Table 2 The incidence of sICH and the association of sICH versus no sICH in 3077 patients treated with EVT for stroke in the anterior circulation

Univariable logistic regression model		
Variable	**OR (95% CI)**	**P value**
Occlusion site		
M1	REF	REF
M2 and beyond	0.95 (0.62 to 1.47)	0.822
ICA	1.58 (1.06 to 2.35)	0.026*

Multivariable logistic regression model			
Variable	**sICH % (n) within variable**	**OR (95% CI)**	**P value**
Occlusion site			
M1	4.2 (71)	REF	REF
M2 and beyond	4 (30)	1.02 (0.63 to 1.64)	0.952
ICA	6.4 (39)	1.58 (1.01 to 2.46)	0.044*
Sex			
Female	4.6 (71)	REF	REF
Male	4.5 (69)	1.02 (0.7 to 1.48)	0.93
Risk factors			
Age	NA	1.01 (1 to 1.03)	0.174
Hypertension	4.8 (88)	0.87 (0.57.1.31)	0.494
No hypertension	4.1 (50)	REF	REF
Diabetes	6.9 (37)	1.72 (1.11 to 2.66)	0.014*
No diabetes	4 (101)	REF	REF
Antithrombotic drug at admission			
No drug	3.9 (71)	REF	REF
VKA/OAC	5.1 (28)	1.91 (1.14 to 3.22)	0.015*
SAPT	5.6 (37)	1.39 (0.87 to 2.21)	0.173
DAPT	12.9 (4)	5.03 (1.63 to 15.5)	0.005*
Stroke characteristics			
NIHSS score before EVT	NA	1.01 (1 to 1.05)	0.476
ASPECTS 5–10	4.3 (122)	REF	REF
ASPECTS 0–4	6.8 (6)	1.61 (0.63 to 4.15)	0.626
IVT	5.1 (75)	1.62 (1.07 to 2.43)	0.021*
No IVT	4.1 (65)	REF	REF

*Statistically significant.
ASPECTS, Alberta Stroke Program Early CT Score; DAPT, double antiplatelet treatment; EVT, endovascular thrombectomy; ICA, internal carotid artery; IVT, Intravenous thrombolysis; M1, M1-segment of middle cerebral artery; M2, M2-segment of middle cerebral artery; NA, not applicable; NIHSS, National Institutes of Health Stroke Scale; OAC, oral anticoagulant; REF, reference; SAPT, single antiplatelet treatment; sICH, symptomatic intracranial hemorrhage; VKA, vitamin K antagonist.

CONCLUSION

In this nationwide unselected EVT cohort, we found significant differences in the frequency and severity of ICH between vessel occlusion sites. EVT treatment in the ICA occlusion site resulted in fewer, but more severe, hemorrhages, such as IVH and PH2, of which the vast majority was classified as sICH. EVT treatment in and beyond the M2 occlusion site resulted in a higher frequency of SAH and HI1-type bleedings, and simultaneously the lowest frequency of sICH.

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Contributors All authors contributed to the design of the study. EH wrote the first draft. EH, TU, and JW collected the data. EH and TU did the statistical analysis. All authors have read and approved the final version of the manuscript. JW is the guarantor.

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Competing interests EH received funding from the Swedish Stroke Federation. JW is a founder and shareholder of Uman Sense AB and has received speaker honoraria from Siemens Healthineers, BALT group, and Medtronic Inc. TU received speaker honoraria from AstraZeneca and Siemens Healthineers and is a steering committee member of Riksstroke.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Swedish ethical review authority (#2019/00678).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. An aggregated dataset may be shared upon reasonable request including the necessary permissions.

ORCID iDs
Emma Hall http://orcid.org/0009-0002-0026-974X
Teresa Ullberg http://orcid.org/0000-0002-6717-0915
Johan Wasselius http://orcid.org/0000-0003-1896-381X

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