Severity of intracranial carotid artery calcification in intracranial atherosclerosis-related occlusion treated with endovascular thrombectomy

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Abstract

Objectives

Intracranial atherosclerosis related large vessel occlusions (ICAS-O) are challenging to diagnose and manage. The degree of intracranial carotid artery calcification may assist pre-thrombectomy diagnosis of ICAS and guide treatment strategy. The aim of the study is to determine if intracranial carotid calcification is associated with ICAS-O.

Patients and ~~M~~methods

Consecutive large vessel occlusion patients who underwent thrombectomy from 2006 to 2017 were retrospectively studied. Patients were classified into ICAS-O if pre-existing atherosclerotic lesion was identified as the etiology for large vessel occlusion during the thrombectomy. The degree of intracranial carotid artery calcification (ICAC), technical and clinical outcomes of ICAS-O was compared with non-ICAS-O patients.

Results

In a retrospective cohort study of 64 thrombectomy patients, ICAS-O accounted for 14.1% of cases and was associated with higher degree of carotid calcification (mean Woodcock scale 2.8 vs 1.6, $p = 0.044$), need of stent-retreiver rescue (55.6% vs 5.5%, $p = 0.001$), and adjuvant stenting or angioplasty (33.3% vs 0%, $p = 0.002$) compared with non-ICAS-O.

Conclusion

The severity of ICAC may be associated with ICAS-O as the underlying etiology amongst thrombectomy patients. Compared with large vessel occlusion of other causes, ICAS-O was associated with more failure of aspiration and a higher need of adjuvant stenting and angioplasty.

Keywords: Thrombectomy; Intracranial atherosclerosis; Intracranial calcification

1 Introduction

Intracranial atherosclerosis (ICAS) is an important cause of stroke, especially amongst Asian populations. In anterior circulation large vessel occlusions, ICAS was the culprit in 5.5% of patients in a French study, 15–22.9% in Korean cohorts, and up to 34% in the Chinese EAST study [1–3]. While the clinical outcomes were similar in ICAS-related large vessel occlusions (ICAS-O) and other causes of stroke, there were unique therapeutic considerations in ICAS-O such as the potential need for permanent stenting, angioplasty or intra-arterial thrombolysis~~[1,4]~~ [1,4]. It would therefore be informative for treatment decision and planning if ICAS-O could be diagnosed before thrombectomy.

Intracranial calcification is associated with ICAS and stenosis of intracranial vessels [5], and recent studies suggest calcification along the vertebrobasilar arteries was more common in posterior circulation ICAS-O [6]. This study investigates the clinical significance and diagnostic value of intracranial carotid artery calcification (ICAC) in identifying potential ICAS-O patients who require endovascular thrombectomy for large vessel occlusion.

2 Patients and Methods

Consecutive patients treated with endovascular thrombectomy for acute large vessel occlusion stroke between January 2006 and May 2017 were included in this retrospective study. The baseline clinical and imaging characteristics, thrombectomy procedure details, angiographic and clinical outcomes were reviewed. The large vessel occlusions were classified into ICAS-O if during thrombectomy there was clear evidence of pre-existing atherosclerotic lesion causing 50% or more luminal stenosis in the target vessel segment after recanalization.

ICAC was determined on the 2 mm thick axial images of the non-contrast computed tomography obtained at the diagnosis of acute large vessel occlusion. The severity of ICAC on the ipsilateral ICA was graded using the Woodcock scale, which assessed the thickness and continuity of carotid calcifications with grade 0 indicating no calcification, and grade 4 indicating thick circumferential calcifications [7]. In addition, the maximal thickness of the carotid calcification was measured.

In accordance with the local practice, all patients underwent an aspiration-first thrombectomy approach, and stent-retriever was used as rescue therapy when aspiration was unsuccessful [8]. Adjuvant stenting or balloon angioplasty of the vessel segment was performed at the operator's discretion if there was early re-occlusion, defined as re-thrombosis or progressive flow-limiting stenosis at the final control angiogram 15 minutes after initial successful revascularization. Univariate analysis was performed to identify risk factors for ICAS-O, and p-value less than 0.05 was considered significant. Statistical analysis was performed with SPSS version 21 (IBM, CA, USA).

3 Results

In the cohort of 64 patients with a mean age of 63.4 years (range 20–92), ICAS was identified in 9 (14.1%) of patients. Cardioembolism was the most common non-ICAS-O etiology and accounted for 64 (71.9%) of cases. The demographic and stroke risk factors between ICAS-O and non-ICAS-O groups were comparable except for the higher prevalence of atrial fibrillation in the non-ICAS-O group (26 patients (47.3%) in non-ICAS-O vs 1 patient (11.1%) in ICAS-O, p = 0.042).(Table 1) Among the ICAS-O patients, the site of occlusion was MCA in 78%, terminal ICA in 22%, and none in the posterior circulation.

Table 1 Clinical characteristics of ICAS-O and non-ICAS-O patients.

alt-text: Table 1

	ICAS-O (n = 9)	Non-ICAS-O (n = 55)	p-value
Age (mean, SD)	66.8 (15.5)	63.9 (17.1)	0.63
Male	88.9%	61.8%	0.15
Smoker	44.4%	20.0%	0.20
Hypertension	77.8%	52.7%	0.28
Hyperlipidemia	0%	14.5%	0.58
Diabetes mellitus	33.3%	25.5%	0.69
Atrial fibrillation	11.1%	47.3%	0.04
Baseline NIHSS (mean)	18.3	23.0	0.10
Posterior circulation stroke	0%	12.7%	0.33

ICAS-O: Intracranial atherosclerosis associated occlusion; NIHSS: National Institute of Health Stroke Scale; SD: standard deviation.

The mean Woodcock scale for ICAC was significantly higher in the ICAS-O group compared to non-ICAS-O (2.8 vs 1.6, p = 0.044). There was also a non-significant trend of thicker maximal carotid calcifications in the ICAS-O group (1.3 mm vs 0.9 mm, p = 0.116). ICAS-O was associated with significantly higher need of rescue therapy with stent –retriever after failed aspiration thrombectomy (55.6% vs 5.5%, p = 0.001) and adjuvant stenting and angioplasty due to early reocclusion (33.3% vs 0%, p = 0.002). (Table 2) Among the 3 patients who required stenting, 2 were treated by deploying the Solitaire AB stent-retriever (Medtronic, USA) and 1 with Wingspan stent (Stryker, USA). There was no significant difference in the final rate of successful reperfusion (defined as TICI2b/3), symptomatic intracranial hemorrhage, functional independence at 90 days (modified Rankin scale 0–2), and mortality between ICAS-O and

non-ICAS-O.

Table 2 Severity of internal carotid artery calcification and thrombectomy outcomes.

alt-text: Table 2

	ICAS-O	Non-ICAS-O	p-value
Internal carotid artery calcification			
Mean ICAC grade (Woodcock scale)	2.8	1.6	0.044
Maximal calcification thickness	1.3 mm	0.9 mm	0.116
Thrombectomy outcomes			
TICI 2b/3	88.9%	78.2%	0.672
Groin to reperfusion time, mean,(SD) minutes	109 (88)	92 (82)	0.575
Rescue therapy with stent retriever after aspiration	55.6%	5.5%	0.001
Permanent stenting / angioplasty	33.3%	0%	0.002
24-hour NIHSS improvement (mean)	6.8	12.4	0.359
Symptomatic intracranial hemorrhage	11.1%	16.4%	0.571
mRS 0~~-2~~ –2 at 90 days	55.6%	30%	0.249
Mortality at 180 days	16.7%	27.9%	0.490

ICAC: Intracranial carotid artery calcification; mRS: modified Rankin Scale; NIHSS: National Institute of Health Stroke Scale; SD: standard deviation.

4 Discussion

The diagnosis and management of ICAS-O remains a relevant challenge in the setting of thrombectomy for acute ischemic stroke, especially in Asian patients in whom ICAS is more prevalent~~[2]~~ [2]. The present study demonstrated that the severity of ICAC may be associated with ICAS-O as the underlying etiology in patients with acute large vessel occlusion. This could potentially inform thrombectomy strategy and favoured the use of stent-retriever as a first-line strategy in patients with significant carotid calcifications, and the possible need for adjuvant angioplasty or stenting~~[1,9]~~ [1,9].

Kim et al., first identified the association between the presence of vessel calcification and ICAS-O in the posterior circulation, but did not find such association in the anterior circulation in their cohort~~[6]~~ [6]. In contrast, all the ICAS-O in our cohort had anterior circulation occlusions. Furthermore, we postulated the severity of calcification, rather than simply the presence or absence of calcification, may be of more clinical value in predicting ICAS-O. Woodcock et al. in their original publication showed that severe calcification, but not mild to moderate calcification, predicted significant ipsilateral carotid stenosis~~[7]~~ [7]. Using the same ICAC grading scale and measuring the maximal calcification thickness, we demonstrated that the calcification severity of ICAS-O patients was significantly higher than non-ICAS-O.

Apart from diagnostic implication in the underlying stroke etiology, ICAC may be of prognostic significance as well. In a recent Spanish cohort, ICAC volumes were associated with incomplete revascularization, poorer functional outcome, and higher mortality~~[10]~~ [10]. Over half of the patients with ICAS-O and heavy carotid calcification failed aspiration thrombectomy. This is likely due to a combination of difficulty in manoeuvring large bore aspiration catheters pass the heavily calcified and irregular carotid siphon, and the relative ineffectiveness of aspiration in removing ICAS-related clot. Severe ICAC may therefore be an indication of using stent-retriever as a first-line approach. Regarding clinical risk factors for ICAS-O, similar to previous studies in Korea, we found male gender and smoking were more common in the ICAS-O group, while atrial fibrillation was associated with non-ICAS-O~~[2,11]~~ [2,11].

Our study is limited by the retrospective nature and small sample size. ICAS-O remained an infrequent but challenging subgroup of patients that require special considerations during thrombectomy. While the preliminary findings on ICAC need to be validated in a larger cohort, this study highlighted the potential clinical value of assessing ICAC in large vessel occlusion patients requiring thrombectomy.

5 Conclusion

The severity of ICAC may be associated with ICAS-O as the underlying etiology amongst thrombectomy patients. Compared with large vessel occlusion of other causes, ICAS-O was associated with more failure of aspiration and a higher need of adjuvant stenting and angioplasty, but clinical outcomes were similar. Larger cohort studies are needed to confirm these preliminary findings.

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Declaration of interest

None.

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Highlights

- Intracranial ICA calcification is associated with ICAS-related vessel occlusion.
- ICAS-related occlusions had higher failure rate after aspiration thrombectomy.
- Adjuvant stenting and angioplasty may be required ICAS-related occlusions.

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