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Combined Surgical and Endovascular Carotid Access for Endovascular Thrombectomy in Acute Ischemic Stroke

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■ OBJECTIVE: Conventional carotid catheterization is impossible in 2%—5% of acute stroke cases. Surgical carotid cutdown may be a necessary bailout strategy to allow for carotid access. We assessed the effectiveness and safety of surgical carotid cutdown for vascular access in interventional acute stroke treatment.

■ METHODS: We compare imaging and clinical data of 15 consecutive patients, in whom we performed a carotid cutdown for acute stroke treatment with 10 consecutive patients, in whom treatment was discontinued because transfemoral access to the occlusion site was not possible.

■ RESULTS: Baseline characteristics of both groups were comparable ($P \geq 0.065$). Cutdown patients had significantly smaller infarctions ($P = 0.031$), significantly more often favorable clinical outcome (38% vs. 0% modified Rankin score 0—2, $P = 0.046$), and a lower mortality (31% vs. 60%, $P = 0.222$) at 3 months. Other than a small hematoma at the operation site, there were no procedure-related complications.

■ CONCLUSIONS: Carotid cutdown is an effective bailout strategy for acute stroke patients, in whom conventional catheterization is not possible.

INTRODUCTION

Access to the intracranial occlusion site can be a time-consuming factor in interventional stroke treatment. In the majority of cases, carotid access can be achieved via femoral puncture and catheterization of the aortic arch within minutes. However, anatomical variants and pathologies such as Leriche syndrome or carotid tortuosity and/or stenosis may render carotid access time-consuming or even impossible.[1,2] It has been shown that transfemoral carotid access in complicated cases takes 20—90 minutes and fails in up to 5% of cases, which again worsens clinical outcome.[1,3] In these cases, bailout strategies such as radial/brachial or carotid puncture may be necessary.[1,3-7] However, even these bailout strategies may be insufficient or fail, for example, if there is extreme tortuosity or high-grade carotid stenosis.[8] In these cases, a hybrid procedure consisting of a surgical access to the carotid artery (carotid cutdown) and consecutive transcarotid endovascular thrombectomy may be considered.[4] In this brief report, we present our retrospective clinical experience with a series of 15 consecutive patients, in whom we performed such a hybrid procedure for acute stroke treatment and we compare these patients with 10 consecutive patients, in whom interventional stroke treatment was discontinued because access to the occlusion site was not possible.

MATERIALS AND METHODS

Patients and Procedures

Patient selection, surgical access, and endovascular thrombectomy were performed as reported previously.[4,9] Data for this study were derived from our prospectively maintained stroke registry. Our local ethics board approved this study and waived the need for explicit patient consent for this retrospective analysis. Our hospital is a tertiary stroke center with a catchment area of approximately 1.2 million inhabitants. All thrombectomies are performed with general anesthesia.

We notify our vascular surgery team, which is available 24/7, whenever access to the occlusion site via femoral or radial/brachial access is expected to be difficult. This can be the case after initial computed tomography (CT) angiography or several futile

catheterization attempts (usually after 20 minutes of catheterization in the aortic arch). The vascular surgery team is then on hold in our angiography suite. If conventional access to the intracranial occlusion site (including via a brachial or radial access) is considered impossible or has not been achieved within 45 minutes after femoral/brachial/radial puncture, we perform a combined surgical and endovascular thrombectomy involving 1) surgical access to the carotid artery with or without additional eversion carotid endarterectomy (eCEA) in our angiography suite, 2) endovascular thrombectomy, and 3) surgical closure of the access site (**Figure 1**).[4] No modifications of medical treatment are made for surgery; hence, intravenous thrombolysis is continued during surgery.

We compared procedural, imaging, and clinical outcome of A) patients receiving our cutdown procedure ("cutdown group") with B) patients in whom endovascular stroke treatment was discontinued because access was impossible and surgery was not available ("discontinuation group"). Surgery was not attempted in these patients, either because this approach was not our standard of care at that time or because the surgical team was not available. Between October 2010 and August 2018, 800 patients were admitted for endovascular thrombectomy for acute stroke in the anterior circulation in our institution. We identified 15 consecutive patients (1.9%) in whom we performed a carotid cutdown to achieve access to the carotid artery and 10 consecutive patients (1.3%) in whom endovascular stroke treatment was discontinued. Carotid cutdown was chosen in 8 cases because catheterization via femoral (n = 8) and additional brachial and carotid (each n = 1) puncture failed. Taken together with the 10 patients from the discontinuation group, this resulted in an overall failure rate for

carotid catheterization of 2% (18/800). In the remaining 7 patients of the cutdown group, the decision for primary cutdown was made after CT angiography, which showed high-grade stenosis of the carotid artery with or without extreme tortuosity and a complicated aortic arch. Portions of the cutdown patient population have been reported on previously.[4]

Infarction size was assessed using the Alberta Stroke Program Early CT Score.[10] Reperfusion was defined according to the modified treatment in cerebral infarction score.[11] Puncture-to-discontinuation time was defined as the time between femoral puncture and discontinuation of interventional treatment in the discontinuation group and between femoral puncture and beginning of surgery in the cutdown group. Duration of cutdown was defined as time between beginning of carotid cutdown and first digital subtraction angiography imaging via carotid access. Duration of thrombectomy was defined as time between first digital subtraction angiography imaging via carotid access and first recanalization.

Statistics

We used Mann–Whitney U tests and Fisher exact tests whenever applicable. P values under the alpha level of 0.05 were defined as significant. All statistical analyses were performed with SPSS 25 software (IBM, Armonk, NY).

RESULTS

Results are summarized in **Table 1**. In summary, baseline characteristics were comparable, but final infarction size was
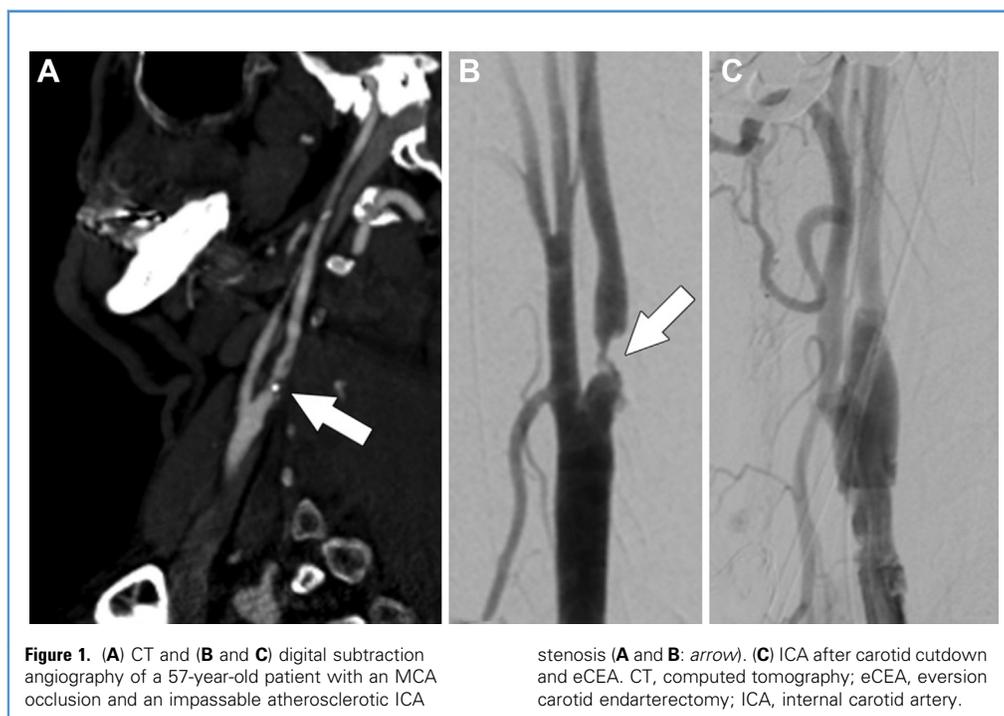

Figure 1. (**A**) CT and (**B** and **C**) digital subtraction angiography of a 57-year-old patient with an MCA occlusion and an impassable atherosclerotic ICA stenosis (**A** and **B**: *arrow*). (**C**) ICA after carotid cutdown and eCEA. CT, computed tomography; eCEA, eversion carotid endarterectomy; ICA, internal carotid artery.

Table 1. Patient Characteristics

	Cutdown Group (n = 15)	Discontinuation Group (n = 10)	P
Age, y	78 (IQR, 72–83)	77.1 (IQR, 72–86)	0.698
Male, n	8/15 (53%)	6/10 (60%)	1.0
NIHSS upon admission	17 (IQR, 11.5–21.5)	20 (IQR, 17–21)	0.353
mRS upon admission	4 (IQR, 4–5)	5 (IQR, 5–5)	0.130
Baseline ASPECTS	9 (IQR, 8.5–10)	8 (IQR, 7–9)	0.065
ICA stenosis, n	9/15 (60%)	5/10 (50%)	0.697
Occlusion reaching extracranial ICA	5/15 (33%)	6/10 (60%)	0.241
Unknown time window, n	10/15 (67%)	3/10 (30%)	0.111
Intravenous thrombolysis, n	6/15 (40%)	7/10 (70%)	0.226
Onset-to-door, min	101 (IQR, 61–154.5)	121 (IQR, 87–170)	0.569
Door-to-image, mi	22 (IQR, 19–31)	23 (IQR, 21–31)	0.815
Image-to-puncture, min	53 (IQR, 42–72)	55 (IQR, 33–73)	0.973
Puncture-to-discontinuation, min	85 (IQR, 62.5–85)	74 (IQR, 43–74)	0.351
Duration of cutdown, min	35 (IQR, 28.5–53)	—	—
Duration of thrombectomy, min	20 (IQR, 13–20)	—	—
Image-to-revascularization, min	168 (IQR, 140.5–168)	—	—
TICI ≥2b, n	12/15 (80%)	0/10	<0.001
TICI 3, n	9/15 (60%)	0/10	<0.001
Final infarction size (ASPECTS)	7 (IQR, 6–8.5)	4 (IRQ, 3–7)	0.031
Parenchymal hemorrhage, n	1 PH1 (7%)	1 PH1 (10%)	1.0
Symptomatic hemorrhage, n	0/15 (0%)	0/10 (0%)	—
mRS 0–2 at 3 months, n*	5/13 (39%)	0/10 (0%)	0.046
Death at 3 months, n*	4/13 (31%)	6/10 (60%)	0.222

ASPECTS, Alberta Stroke Program Early CT Score; ICA, internal carotid artery; IQR, interquartile range; mRS, modified Rankin score; NIHSS, National Institutes of Health Stroke Scale; TICI, thrombolysis in cerebral infarction.

significantly smaller, and clinical outcome was significantly more favorable in the hybrid group.

Time between first diagnostic imaging and initiation of surgery was considerably but nonsignificantly shorter when surgery was the primary access of choice with a median of 92 minutes (interquartile ratio [IQR], 38–109) compared with 126 minutes (IQR, 99.5–145.5) (P = 0.12). Seven patients (44%) received eCEA, which was performed before thrombectomy in 6 patients and after thrombectomy in 1 patient. If additional eCEA was needed, carotid access took markedly but nonsignificantly longer with a median of 53 minutes (IQR, 41–56) compared with 30 minutes (IQR, 28–35) (P = 0.06). After carotid access was established, thrombectomy was finalized after a median of 1 pass (IQR, 1–2). Other than a small hematoma at the operation site, there were no procedure-related complications.

DISCUSSION

Although the vast majority of thrombectomy patients can be treated conventionally, there is a small proportion of patients in whom conventional carotid access is not possible. Given the disastrous natural history of untreated large-vessel stroke, no efforts should be spared to allow for thrombectomy. Despite the limitations of our small sample size and the consecutive selection bias, our results show that surgical carotid cutdown is a feasible bailout strategy with clinical results that are comparable to those of the large randomized thrombectomy studies.[12] In summary, baseline characteristics were comparable in the 2 groups, but final infarction size was significantly smaller and favorable clinical outcome was significantly more often in the cutdown group (38% vs. 0%). Notably, surgical cutdown was not associated with relevant procedure-related complications even though 40% of our patients had received thrombolysis.

The main questions are whether the time needed for carotid cutdown should have been invested in more catheterization attempts and whether an alternative approach could have worked out equally. These questions are highly hypothetical and their response depends not only on the patients' anatomy but also on individual factors such as the materials used and the interventionalists' skills. Ribo et al. indicate a failure rate of 5% for transfemoral carotid catheterization in a tertiary stroke center with experienced interventionalists, which is in agreement with the failure rate of 2% in our institution.[1] Hence, it is fair to assume that failed carotid catheterization is a rare but possible event in high-volume stroke centers. Consequently, the question is not if interventionalists may face an impossible intracranial access, but rather what bailout strategies they have when this situation occurs. A radial or brachial access may help to bypass iliac or aortic stenosis.[6,7] However, such an approach necessitates using smaller devices for thrombectomy and will not overcome difficulties posed by carotid tortuosity and stenosis.[7] The simplest approach in a difficult carotid access, which cannot be overcome with balloon angioplasty or stenting, is to avoid carotid catheterization altogether and to apply intra-arterial thrombolysis without further catheterization. In a meta-analysis, intra-arterial thrombolysis was shown to achieve favorable clinical outcome (modified Rankin score 0–2) in 43% of cases.[13] However, favorable outcome rates are expected to be half as high (17%), if

there is involvement of the internal carotid artery, which is the case in many patients with difficult carotid access.[14] Transcutaneous carotid puncture on the other hand may allow for fast and secure access to the carotid artery and eliminates the need for instrumentation of the aortic arch.[3] However, direct carotid puncture will neither overcome difficulties posed by subsequent carotid stenosis. Also, even in the absence of relevant atherosclerosis, puncture of the carotid artery may be difficult because of its thick vessel wall, with potentially severe puncture-related complications (dissections and hematomas) reported in 2.4%−10.7%.[3-5,15] Also, closure of the carotid puncture site remains a problem, because there are no occlusion devices that are approved for carotid occlusion.[3,16] Carotid cutdown on the other hand has the advantages of direct carotid puncture but a minor procedure-related complication rate of 0.8%−1.9%, albeit these numbers have to be treated with caution because comprehensive data derived from larger acute stroke populations are lacking.[4] Notwithstanding, carotid cutdown appears to be relatively safe and it is also a major advantage of our approach that stenting and dual platelet treatment with its consecutively

increased hemorrhage risk of approximately 14% can be avoided.[17] Major disadvantages of this approach remain its limited availability and its costs, which limit the generalizability of our approach. Another major limitation is the duration of our approach. Notably, median duration of cutdown and thrombectomy were only 35 and 20 minutes, respectively, but a median of 92 minutes from first CT to initiation of surgery in anticipated cases reflects the complexity of this procedure and the need for improvement of infrastructural and organizational processes; for example, identifying adequate patients early on, workflow optimization with surgical equipment in the angiography suite, and performing eCEA after instead of before thrombectomy whenever possible.

CONCLUSION

Carotid cutdown is an effective bailout strategy for vascular access in acute stroke patients in whom conventional catheterization is not possible.

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