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Outcomes after Transverse-Incision 'Mini' Carotid Endarterectomy and Patch-Plasty

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Purpose: Traditional exposure for carotid endarterectomy (CEA) involves making a longitudinal incision parallel to the anterior border of the sternocleidomastoid. Such incisions can be painful, aesthetically displeasing, and associated with a high incidence of cranial nerve injury (CNI). This study describes the outcomes of CEA performed through small (<5 cm long), transversely oriented incisions located directly over the carotid bifurcation, as identified by color-enhanced Duplex ultrasound.

Materials and Methods: Patient demographics and operative data were collected retrospectively from an in-house database of consecutive vascular patients undergoing CEA with a small transversely oriented incision for both symptomatic and asymptomatic carotid artery stenoses.

Results: A total of 52 consecutive patients underwent CEA between 2012 and 2016 (median age, 73.5 years; interquartile range, 67-80.3; male/female ratio, 40:12). CEA was performed under regional/local anesthesia (LA) in 48 (92.3%) patients, with 4 (7.7%) being performed under general anesthesia. One patient under LA experienced neurological dysfunction intraoperatively (manifesting as an inability to count out loud) that resolved with insertion of shunt. One patient experienced a transient neurological event (expressive dysphasia) within the immediate postoperative period, which resolved within 6 hours. No in-hospital death or perioperative major adverse cardiovascular events were noted. No persistent CNIs nor bleeding complications necessitating re-exploration were reported. Follow-up data were available for a median period of 3.1 years and for all patients. Three patients experienced strokes following discharge (2 strokes contralateral to and 1 transient ischemic attack ipsilateral to the operated side).

Conclusion: Small, transversely orientated incisions, hidden within a neck skin crease can be safely performed in the majority of patients undergoing CEA.

Key Words: Carotid endarterectomy, Carotid artery stenosis, Vascular surgical procedure, Outcome assessment

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INTRODUCTION

Carotid endarterectomy (CEA) remains the gold standard intervention to reduce the risk of symptomatic high-grade carotid artery stenosis [1]. The traditional CEA exposure is described as a longitudinal incision parallel to the anterior border of the sternocleidomastoid extending from the angle of the mandible to just above the suprasternal notch. Such incisions can be painful, cosmetically displeasing, and have been reported to result in cranial or cervical nerve (CCN) injury rates of up to 80% [2-5].

Shorter longitudinal incisions have been postulated to be associated with the reduced risk of cranial nerve injury (CNI), whereas transversely sited skin-crease incisions may offer improved cosmesis without increasing the risk of CNI [2,6,7]. The risk of suboptimal exposure of the carotid lesion with shorter or transverse incisions can be reduced by identifying the level of the bifurcation preoperatively, and various methods have been employed to achieve this including the use of color-enhanced Duplex ultrasound (CDUS), magnetic resonance imaging, and skin surface anatomy or landmarks [2,3,5,8,9].

The purpose of this study was to describe the outcomes following CEA performed in unselected, consecutive patients with a short (<5 cm length), transversely oriented skin crease incision sited directly over the carotid bifurcation as localized with the on-table CDUS.

MATERIALS AND METHODS

1) Patient cohort

Consecutive patients undergoing CEA performed by a single surgeon (author: VMG) from January 2012 to December 2016 were identified from an in-house database of patients with vascular disease. Institutional Research Board approval was not required as this was considered a retrospective, anonymised, case note review which complied with National Health Service guidelines for clinical audit and service development. Informed, signed consent was gained from the specific patient whose intra-operative photographs appear in Fig. 1.

2) Data collection

Patient demographic, preoperative imaging, operative, and postoperative data were retrospectively collected by reviewing electronic medical records and supplemented by an individual case note review. Symptomatic carotid disease was clinically defined as cerebral symptoms plausibly secondary to carotid emboli (e.g., amaurosis fugax, dysphasia, facial droop, extremity weakness) with or without confirmatory radiological evidence of ischemic infarcts on brain imaging.

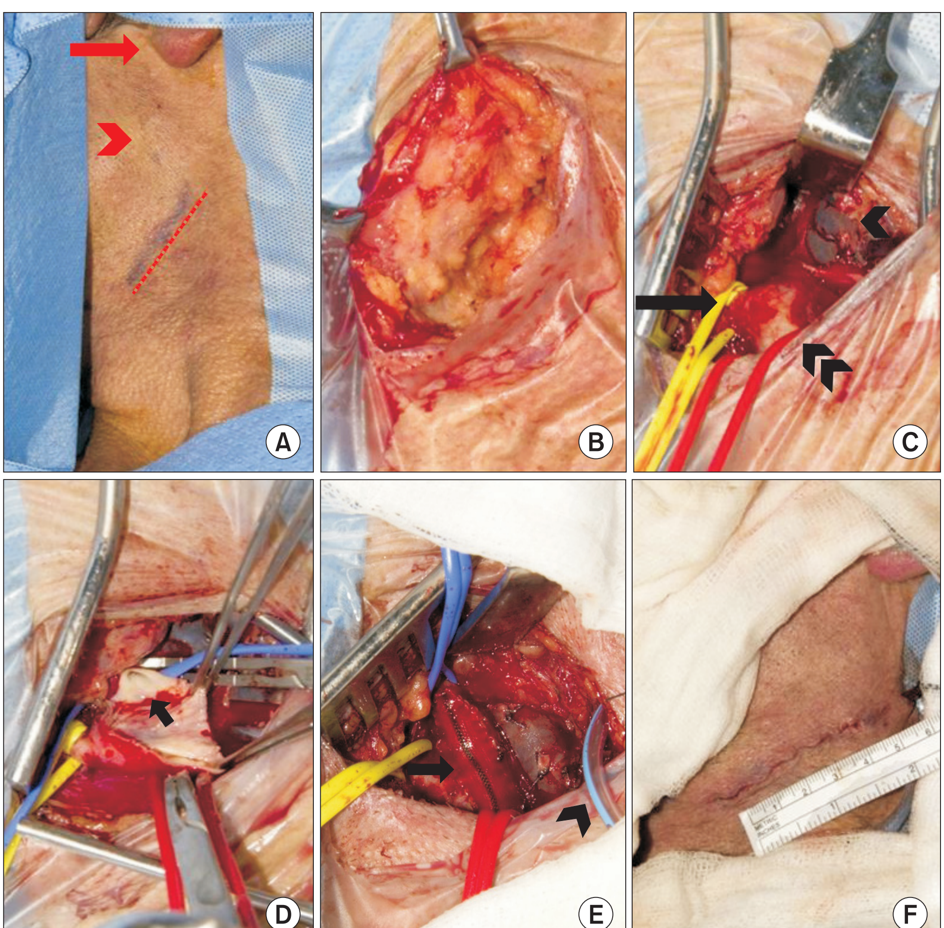

Fig. 1. (A) Preoperative marking of (left) carotid bifurcation (arrow, earlobe; arrowhead, mandibular angle). (B) Raising of subplatysmal flaps. (C) Ventro-jugular exposure of carotid bifurcation (black arrow, external carotid artery; single arrowhead, internal jugular vein; double arrowhead, common carotid artery). (D) View of endarterectomized vessel (black arrow, distal intimal margin). (E) View of reconstructed carotid artery with Dacron patch (black arrow); suction drain is also visible (arrowhead). (F) View of closed incision following carotid endarterectomy.

3) Perioperative care

Preoperative imaging was performed with CDUS and computed tomography angiography (CTA) to confirm the site and severity of stenosis. Carotid severity stenosis was graded by CDUS using the recommended guidelines of the North American Symptomatic Carotid Endarterectomy Trial criteria [10]. CTA and CDUS were also used to identify patients anticipated to have challenging surgical access such as high carotid bifurcations (defined as <10 mm from the angle of the mandible) or cases of diffuse disease (e.g., with extension of stenosis into the intracranial portion of the internal carotid artery [ICA]).

The standard anesthetic approach for CEA was performed under regional cervical blockade. General anesthesia (GA) was utilized per patient's choice. Intravenous antibiotics were routinely administered at induction.

Once positioned on the operating table with neck extension and an interscapular bolster, CDUS was performed (Sonosite S-Nerve portable ultrasound with an HFL38×13-6 MHz linear array transducer) to identify the level of the carotid bifurcation and the position of the internal carotid artery. The position of the bifurcation was marked using a skin marker and a transverse incision planned in the nearest overlying neck skin crease. All incisions were planned to be ≤5 cm in length (Fig. 1A).

The surgical technique was standardized. Thus, transversely oriented subplatysmal flaps were raised (Fig. 1B), and a ventrojugular approach was performed to reach the carotid bifurcation (Fig. 1C). The hypoglossal nerve was protected when encountered but was not routinely sought. The vagus nerve and ansa cervicalis were routinely identified and protected. Control of the carotid vessels and endarterectomy was performed in the standard fashion with systemic heparin routinely administered prior to cross-clamping (Fig. 1D). Distal intimal tacking sutures (7-0 prolene) were used in all patients, and reconstruction was performed either with a synthetic Dacron patch (Hemagard Tapered Carotid Patch; Maquet-Getinge Group, Rastatt, Germany) (Fig. 1E) or a biological patch (Xenosure Biologic Patch; LeMaitre Vascular Inc., Burlington, MA, USA). The quality of the completed patch reconstruction was assessed using a hand-held continuous wave Doppler. In patients who were under GA, shunting was performed routinely (Javid Carotid Bypass Shunt, Bard Peripheral Vascular Inc., Tempe, AZ, USA). Shunts were not used for patients under regional blockade unless the patient developed intraoperative neurology. The eversion technique for endarterectomy was not used. Wounds were closed in three layers with absorbable sutures over a suction drain (Fig. 1F). Systemic heparinization was not routinely reversed. Postoperatively, patients were admitted to the high dependency unit for overnight monitoring.

All patients underwent a cranial nerve neurological examination immediately prior to discharge and again at the outpatient clinic follow-up. Outpatient clinic follow-up was performed at 6 weeks postoperatively and was based on symptomatic progress and clinical examination. Routine postoperative imaging with Duplex US or CTA was not performed. Cranial nerve examination was performed by a senior vascular surgical team member (either consultant or higher trainee) and mirrored the approach described in other published series, whereby CNIs were defined as motor deficits involving the cranial nerves VII, IX, X, XI, and XII, and the sympathetic chain (Horner syndrome) [11,12]. Cutaneous sensory nerves (transverse cervical and greater auricular nerves) were assessed by testing their response to light touch in the appropriate dermatomal area. Seventh nerve palsy was defined as injury to the marginal mandibular branch of the facial nerve, demonstrated by inability to retract the corner of the mouth downward ipsilateral to the side of surgery. Glossopharyngeal nerve impairments were defined as uvula deviation and dysphagia. Vagus nerve injury and its branches were assessed based on difficulty swallowing, hoarseness, and ease of voice fatigue. Spinal accessory nerve injury was assessed based on sternocleidomastoid and trapezius muscle weakness, and hypoglossal nerve injury was assessed based on ipsilateral deviation of

Table 1. Baseline demographics (n=52)

Baseline characteristic	Value
Age (y)	73.5 (67-80.3)
Sex	
Male	40 (76.9)
Female	12 (23.1)
American Society of Anaesthesiology	
Grade 1	0
Grade 2	6
Grade 3	39
Grade 4	7
Co-morbidities	
Hypertension	37 (71.2)
Diabetes	14 (26.9)
Ischemic heart disease	41 (78.8)
Smoking history	29 (55.8)
Presentation	
Symptomatic	44 (84.6)
Asymptomatic (pre cardiac surgery)	5 (9.6)
Asymptomatic (other)	3 (5.8)

Values are presented as median (interquartile range), number (%), or number only.

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the tongue. Major postoperative adverse events were assessed, including intraoperative hemorrhage, new acute ischemic stroke (defined as either radiological evidence of ischemic lesion on axial brain imaging or based on clinical examination by a neurologist or stroke physician), myocardial infarction (MI), and mortality occurring within 30 days postoperatively.

Table 2. Preoperative imaging results

Preoperative imaging	Value
CDUS and CTA	42 (80.8)
CDUS only	4 (7.7)
CTA only	6 (11.5)
Stenosis severity[a]: symptomatic (n=44)	
<50%	2
50%-59%	4
60%-69%	3
70%-79%	13
80%-89%	9
>90%	12
Near occlusion	1
Stenosis severity[a]: asymptomatic[b] (pre cardiac surgery, n=5)	
<50%	0
50%-59%	0
60%-69%	0
70%-79%	1
80%-89%	1
>90%	2
Near occlusion	1
Stenosis severity[a]: asymptomatic[b] (incidental findings, n=3)	
<50%	0
50%-59%	0
60%-69%	0
70%-79%	0
80%-89%	1
>90%	2
Near occlusion	0

Values are presented as number (%) or number only.
CDUS, color-enhanced Duplex ultrasound; CTA, computed tomography angiography.
[a]Stenosis graded by the North American Symptomatic Carotid Endarterectomy Trial criteria.
[b]Stenosis grading of operated side presented (all patients had bilateral disease).

RESULTS

1) Patient demographics

A total of 52 patients underwent CEA between January 2012 and December 2016. Baseline demographics are presented in Table 1. The median age was 73.5 years (interquartile range [IQR], 67-80.3) and 40/52 (76.9%) were male. The median American Society of Anaesthesiology grade was 3. Majority of patients had symptomatic carotid lesions (44/52, 84.6%) (transient ischaemic attack, n=14; stroke, n=30). Out of the 52 patients, eight were asymptomatic, and this cohort consists of two subgroups: patients with bilateral high-grade stenoses incidentally detected during work-up for coronary artery bypass surgery (5/52, 9.6%) and those with high-grade stenoses referred by medical teams (3/52, 5.8%).

Among them, 42 (80.8%) patients underwent preoperative imaging with CDUS and CTA, 4 (7.7%) underwent CDUS only due to past history of iodinated contrast allergy, and 6 (11.5%) underwent CTA only (Table 2). Different grades of stenoses are presented by subgroup in Table 2.

2) Pre and intraoperative characteristics

The median time from symptoms (or referral) to CEA was 8 days (IQR, 6-11.5). The laterality of lesions was similar (i.e., 50% and 50% were right- and left-sided, respectively). The majority (48/52, 92.3%) of patients underwent CEA under regional blockade. Among the 52 patients, 4 (7.7%) underwent CEA under GA. Shunts were used in all patients who underwent GA. One patient (1/52, 1.9%) undergoing CEA under regional blockade experienced intraoperative neurology (manifested as loss of ability to count sequential numbers out aloud when instructed to do so), which was resolved by shunt insertion. There were no conversions from regional blockade to GA. Three of the 52 (5.8%) patients were noted to have carotid bifurcations within 10 mm of the mandibular angle, and no patients had diffuse disease extending to the intracranial ICA. All three patients with high bifurcations had favorable body habitus, and consequent access was still achievable through a transverse incision (albeit placed more cranially as directed by on-table pre-incision CDUS marking). None of the patients required extended incision or any immediate surgical re-exploration.

3) Postoperative outcomes

One patient (1/52, 1.9%) undergoing CEA under regional anesthesia for symptomatic carotid disease experienced an ipsilateral neurological event (expressive dysphagia) within the immediate postoperative period, which was resolved within 6 hours without any residual effects. The median (IQR) length of hospital stay was 1 day (1-2 days). No bleeding complications occurred necessitating either wound re-exploration or blood transfusion. No in-hospital deaths were reported. In terms of perioperative major adverse cardiovascular events, no patients had MI, and the 30-day mortality was 1.9% (1/52 patients), which occurred at postoperative day 10 in a patient who had undergone CEA for symptomatic disease. The cause of death was gastrointestinal perforation and was not considered a sequelae of surgery.

Three patients had postoperative stroke, all of them (5.8%) suffered neurological events following discharge. Two of them developed strokes (upper and lower limb weakness) related to the contralateral hemisphere (i.e., not plausibly related to surgery) at days 10 and 42, postoperatively. Both strokes were based on the clinical diagnosis made by stroke physicians as no acute lesions were evident on CT brain scans. They were known to have 60% and 55% stenoses on the unoperated carotid system and had been imaged preoperatively with both CDUS and CTA. One of the 3 patients suffered a transient ischemic attack (upper limb weakness) ipsilateral to the operated side at postoperative day 20. Brain CT scan did not demonstrate any acute ischemic lesion, and CDUS imaging of the carotid did not reveal any technical defects or evidence of re-stenosis; therefore, this patient was managed conservatively with dual anti-platelet therapy.

One patient who underwent CEA for symptomatic disease developed a chronic wound sinus postoperatively requiring surgical excision (performed 13 months after the initial surgery). Intraoperative histology demonstrated a chronic wound sinus, likely related to the suture material, and the wound subsequently healed completely.

Follow-up was available for a median period of 3.1 years (IQR, 4 months). During this time, 4 more patients died (median time from surgery to death, 362 days; IQR, 1,862) from different causes (two cardiac events, one community-acquired pneumonia, and one ischemic bowel) unrelated to the carotid surgery.

One of the 52 (1.9%) patients who received GA for their CEA complained of hoarse voice and 16/52 (30.8%) patients complained of numbness over the surgical wound but not at the mandibular angle at the point of discharge. During the 6-week outpatient clinic follow-up, 0/52 complained of persistent hypo-sensation at the mandibular angle. There were no instances of persistent hoarse voice or other motor CNI. Only one patient who complained of hoarse voice underwent laryngoscopy which did not demonstrate any evidence of cord palsy. The patient's symptoms settled spontaneously within 3 months. The median length of incision was 5±0.5 cm. There were no cases of haemodynamically significant re-stenosis detected on CDUS at follow-up for any patient in the cohort.

DISCUSSION

Given the critical importance of full exposure of the carotid bifurcation and access to the non-diseased internal carotid artery beyond the stenotic plaque, CEA has traditionally been performed through full-length neck incisions, extending from just inferior to the mastoid process to just above the suprasternal notch and running parallel to the anterior border of the sternocleidomastoid [4,13]. Such extensive incisions may be unnecessary, particularly in patients with a relatively low carotid bifurcation or with a localized diseased segment [6]. Consequently, several cohort studies have demonstrated that shorter longitudinal incisions are technically feasible [2,6,8]. Such "mini" longitudinal incisions are purported to offer improved cosmesis. Whereas one group has reported reductions in the length of hospital stay and CNI rates, others have reported no difference in complication (mortality, stroke, or nerve injury) rates with shorter incisions compared with the traditional access method [2,6,8]. Remarkably, no information on a universally accepted threshold size which classifies an incision as 'small' has been defined in the literature. Different groups have suggested that traditional access incisions can range in length from >7 cm to as long as 17.5 cm [6,8]. Conversely, "mini" longitudinal incisions have been described as those that are <5 to 7 cm in length, with some studies describing successful CEA through longitudinal incisions <2.5 cm in length [2,3,6,8].

In an attempt to shorten the length of the incision, re-orientation of the incision in a transverse or oblique direction in line with the skin creases of the neck (and therefore Langer's lines) has further improved cosmesis [5,9,12,14-17]. Concerns with transversely oriented incisions in CEA were related to the lack of enhanced exposure through the incision extension in instances wherein either the location of the carotid bifurcation or the extent of disease is misjudged preoperatively and to increased difficulty with shunt deployment compared to that through longitudinally oriented incisions [3,13]. Proponents of the technique advice that with the increase in the subplatysmal flap, the use of self-retaining retractors as well as natural laxity of the neck skin is generally possible to gain additional cephalad or caudal exposure as needed [12,14,18]. Recent reports describe the use of specialized ring retractor systems in enabling mini-incision CEA [19,20]. In our practice, a pair of self-retaining retractors (such as a Travers retractor) is used, which en-

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ables re-orientation of the subplatysmal portion of the wound to a horizontal direction, thereby achieving a similar exposure to that with a longitudinal skin incision.

Concerns with transversely oriented incisions appear to have not been reported in several nonrandomized studies and cohort studies demonstrating successful CEA through such incisions with postoperative hematoma, mortality, and stroke rates, without different longitudinal incisions [3,5,12,14,17]. However, while authors have described improved cosmesis based on both subjective and objective wound assessment parameters with transverse incisions, the benefits of a transverse incision in terms of CCN injuries are more controversial [3,12,18]. Therefore, although one nonrandomized study reported a higher risk of marginal mandibular nerve dysfunction with longitudinal incisions, this has not been substantiated by others [3,12,14,18]. Indeed, one nonrandomized study reported a significantly higher rate of ipsilateral temporary vocal cord dysmotility with transverse incisions; however, this finding was significantly confounded in a retrojugular approach using transverse incisions compared with a ventrojugular approach using longitudinal incisions [16]. A meta-analysis of risk factors for CNI after CEA found that expedited surgery and re-exploration for postoperative neurology or bleeding were associated with CNI, while the type of anesthesia, use of shunt, patch reconstruction, and re-do surgery were not [21]. The analysis did not include the type of incision, and therefore as the anatomical first principles would indicate that a transverse incision should be associated with less CCN injury (in particular greater auricular nerve and transverse cervical nerve branches), this remains unproven [13].

It is noteworthy that while transverse-incision CEA has been utilized in the full spectrum of cases (symptomatic and asymptomatic cases, general and regional anesthesia, eversion endarterectomy and patch reconstruction), even proponents of a transverse incision acknowledge potential difficulties with adequate exposure and that in some nonrandomized comparisons, surgeons preferentially utilized a longitudinal incision in patients suspected with “difficult” situations (i.e., patients with high bifurcations or requiring re-do surgery) [13,14].

Our study demonstrates the applicability of targeted “mini” transverse-incision CEA in consecutive patients, with outcomes equivalent to those of published series [18]. We ascribe our success with the method, even in unfavorable patients (i.e., obesity, short necks, high bifurcations, and long plaque), to the accurate localization of the carotid bifurcation with CDUS that enables transverse incision to be appropriately sited. CDUS has been demonstrated to be an effective modality for visualizing the carotid anatomy [13,22]. Other reported methods used to assist in siting of the transverse incision over the bifurcation include the use of skin surface landmarks without adjunctive imaging, skin surface or vertebral level landmarks with adjunctive preoperative magnetic resonance angiography and combinations of imaging modalities (CTA, CDUS, and fluoroscopy) [5,9,12,18]. We would advocate caution in using skin surface landmarks due to the scope for variability according to body habitus, neck size, and coexistent pathology, such as degenerative cervical disc disease, whereas the use of cross-sectional (i.e., CTA or MRA) or otherwise ionizing (i.e., fluoroscopy) imaging modalities would seem to be an overly complex and inefficient use of resource given the effectiveness of CDUS.

We have described the use of continuous-wave handheld Doppler (HHD) for quality assessment, i.e., the standard practice in our unit. It is accepted that there are numerous modalities available for intraoperative quality assessment (such as HHD, CDUS, angioscopy, and angiography), and HHD, although inexpensive, is operator dependent and does not allow visualization of defects; therefore, quantification of blood flow velocity has limitations [23]. However, there remains no universally accepted consensus on the optimal assessment modality, and indeed, recent published series still describe a lack of any form of quality assessment [24].

Limitations of this study include a small sample size and its retrospective nature. However, patients had their surgery performed by one surgeon in one surgical unit, thus removing surgical technique as a potential confounder. Because “mini” transverse-incision CEA is routinely performed in our practice, we did not a have a CEA cohort with longitudinal incisions for comparison; we have instead benchmarked our outcomes against previously published series. It is acknowledged that this is a further limitation and that comparisons against a historical cohort of longitudinally sited incisions would have increased the power of this study. Any retrospective study will be subject to selection bias, and consequently the best way to compare transverse incision with longitudinal incision CEA would be within a well-designed randomized controlled trial. Finally, although CNI examination was performed in accordance with descriptions from published series (and was performed pragmatically as a part of standard postoperative care assessed by the operating team), it is acknowledged that the detection of clinical signs can vary according to observer, and consequently examination performed by specialists such as neurologists may have yielded different results.

CONCLUSION

“Mini CEA” can be safely performed at appropriately experienced high-volume vascular units. We advocate the routine use of on-table CDUS for marking of the carotid bifurcation to guide accurate citing of a small, targeted, transverse incision.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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