Evaluating the Safety of Transcarotid Artery Revascularization under Local Anesthesia Prior to Coronary Artery Bypass Grafting Surgery

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Background: Controversy exists regarding the timing of intervention for patients with critical coronary artery disease (CAD) awaiting coronary artery bypass and severe carotid artery stenosis (CAS). Transcarotid artery revascularization (TCAR) is a minimally invasive revascularization alternative through direct transcervical carotid access that minimizes the chance of arch manipulation and consequent antegrade embolic stroke rate. While the TCAR procedure can be performed under local anesthesia (monitored anesthesia care [MAC]) versus general anesthesia, the hemodynamic benefits of local anesthesia in patients with severe CAD are significant. Patients receiving staged TCAR-coronary artery bypass grafting (CABG) have high-risk cardiovascular disease and require accurate perioperative neurological and hemodynamic evaluation that can be safely provided with local anesthesia.
Methods: In this retrospective single-center study, 14 patients were systematically identified to have undergone staged TCAR prior to CABG surgery from December 2018 to October 2021. All patients underwent TCAR with local anesthesia and minimal sedation. Relevant patient demographics, medical and surgical history, preoperative covariates, and type of anesthesia administered were obtained from patients' charts. CAD was confirmed by either carotid duplex imaging or computed tomography angiography (CTA) of the head/neck.
Results: Staged TCAR-CABG interventions were performed on 14 patients (64% male; mean age 65.0 years). No major adverse cardiac events were reported including transient ischemic attack (TIA), stroke, myocardial infarction (MI), or TCAR-related death in the interval between their TCAR and CABG as well as in a 12-month follow-up period. One patient required to return to the operating room (OR) for evacuation of a neck hematoma.
Conclusions: This study demonstrated high success rate of TCAR under local anesthesia prior to CABG (100%) with no incidence of perioperative stroke, MI, or death at 1-month, 6-month, and 12-month follow-up intervals. The authors support the use of staged TCAR-CABG with local anesthesia as a safe and promising treatment option for patients with high-grade cardiac disease, high risk of stroke, or multiple comorbidities that preclude a carotid endarterectomy (CEA).

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INTRODUCTION

There is a well-established association between carotid artery disease and coronary artery disease (CAD) with 29.8% of patients with multivessel CAD having echographic carotid artery stenosis (CAS).[1] Carotid atherosclerotic disease is a major risk factor of early postoperative stroke and ischemic brain attack after coronary artery bypass grafting (CABG) surgery and is seen in 0.5% to 7% of CABG procedures.[2] Severe carotid stenosis can cause ischemic strokes in patients undergoing CABG by providing an embolic source, decreasing cerebral perfusion, or a combination of both.[3] While the etiology of this complication is multifactorial, previous studies have demonstrated that carotid disease is an independent predictor of mortality and can be managed either before or concomitantly with the CABG procedure in nonemergent evaluations.[4]

Noninvasive imaging such as duplex ultrasonography is the most common imaging modality for AS screening, although computed tomography angiography (CTA) and magnetic resonance angiography are also used in clinical practice.[5] Carotid ultrasonographic techniques can quantify the extent of stenosis by measuring atherosclerotic plaque and thickness of the carotid intima-media for risk prediction of ischemic stroke.[6] To date, carotid endarterectomy (CEA) has been the gold standard of carotid artery revascularization.[7] Patients undergoing CEA receive regional or general anesthetic before the surgeon dissects the carotid artery to remove plaque build-up and improve blood flow through the vessel.[8] The artery is then repaired either primarily or with a patch constructed from a vein or other biologic or artificial material. Common treatment timelines include simultaneous CEA and CABG, staged CEA followed by CABG, and staged CABG followed by CEA.

Most CEA procedures are currently performed under general anesthesia. General anesthesia provides establishment of a secure airway, regulated ventilatory control, and the use of inhaled volatile anesthetics creates a certain margin of cerebral protection.[9] However, studies have shown benefits of local or regional anesthesia that may generate a shift in anesthetic preference. Advocates of these anesthesia techniques consider them safer since the conscious patient allows for better monitoring of cerebral function and avoids depression of cardiac function—a side effect of general anesthesia.[9] Findings of Hussain et al. demonstrated a greater than two-fold increase in mortality in patients given general anesthesia for CEA compared with regional anesthesia. Leichtle et al. independently showed that general anesthesia was a significant risk factor for postoperative MI, especially in those with preoperative neurologic symptoms. In 2017, Knappich et al. correlated local anesthesia with shorter clamp times and lower risk of in-hospital stroke and death. These studies support that this population of high-risk patients with cardiovascular disease fares better with regional or local anesthesia in the setting of CEA surgery, but there is limited data translating these principles to alternative revascularization techniques.

This paper describes an alternative method of revascularization: transcarotid artery revascularization (TCAR) with reversed flow protection performed exclusively under local anesthesia. TCAR utilizes the ENROUTE Transcarotid Neuroprotection System for adequate flow reversal and reduces the risk of embolic events by minimizing endovascular manipulation of the great vessels and aorta. The 2013 ROADSTER trial showed an impressively low perioperative stroke rate of 1.4% with the use of TCAR.[10] However, most completed, high-volume studies have only investigated TCAR under general anesthesia conditions. Williams and Almenoff report data on the safety of simultaneous TCAR-CABG and TCAR prior to cardiac intervention, respectively; however, both specifically describe patients receiving general anesthesia.[2,11]

Considering the numerous anesthetic challenges of patients with multivessel occlusive coronary disease, we performed a retrospective study to review the outcomes of TCAR performed under local anesthesia prior to CABG surgery to characterize any postoperative complications and optimize anesthetic decision-making.[12]

METHODS

This study is a retrospective, single-center case series study that included preoperative CABG patients at the University of Maryland Medical Center with a history of a staged TCAR prior to their CABG surgery. The electronic health records system, Epic, was utilized to extract patients' data using TCAR and CABG codes. All research methods were conducted in accordance with Good Clinical Practice guidelines and institutional review board was obtained. Patient-informed consent was waived by the institutional review board.

Data from adult patients who underwent TCAR between December 2018 and October 2021 were reviewed. The inclusion criteria were defined as patients with CAD and CAS who underwent a planned staged TCAR prior to CABG surgery. The indications for TCAR were symptomatic CAS with stenosis of >50% or asymptomatic CAS with stenosis of >70% and contralateral internal carotid artery (ICA) occlusion or diffuse cerebral occlusive disease on radiographic imaging. Radiographic and patient-specific factors such as high carotid artery bifurcation, restenosis of a previous CEA and prior history of neck radiation, were used to select TCAR versus CEA. We excluded patients who had undergone CEA before CABG, those who underwent a TCAR after CABG, or were recommended for TCAR-CABG but were lost to follow-up before CABG completion.

Relevant patient demographics, medical and surgical history, comorbidities, and type of anesthesia administered were obtained from patients' charts. The preoperative covariates analyzed included body mass index, hypertension, diabetes mellitus, smoking history, and history of transient ischemic attack (TIA) or stroke. Perioperative factors studied included blood loss, blood transfusion, calculated Society of Thoracic Surgeons mortality risk score for isolated CABG, preoperative ejection fraction (%), postbypass ejection fraction (%), and infection at time of surgery. Operative reports, in-patient consultation notes, and out-patient follow-up notes were thoroughly reviewed to identify post-TCAR-CABG major adverse cardiovascular events (MACEs). MACE was defined to include stroke, myocardial infarction (MI), return to operating room (OR) for revascularization, and death. MACEs pertinent to TCAR and CABG up to 6 months following hospital discharge were identified and noted. Carotid artery disease was confirmed by either carotid duplex imaging or CTA of the head/neck.

TCAR Surgical Procedure

All patients underwent standard surgical access to the common carotid artery (CCA) just above the clavicle under local anesthesia, such as lidocaine or bupivacaine, with conscious sedation. A transverse incision was made between the sternal and clavicular heads of the sternocleidomastoid muscle followed by longitudinal division of the carotid sheath. A polypropylene suture was preplaced in the anterior wall of the CCA to facilitate hemostasis upon removal of the arterial sheath at completion of the procedure. A micropuncture needle was inserted into the artery and advanced into the CCA followed by exchange for a microsheath. Angiogram was then performed to isolate location of lesion before introduction of the SilkRoad ENROUTE transcarotid stent system. Once femoral access was obtained, flow reversal catheters were connected and a wire was advanced into the sheath through the lesion and finally into the distal ICA. The lesion was predilated with an angioplasty balloon and under fluoroscopy, a bare metal, self-expanding stent was deployed. Anticoagulation was started either immediately prior to TCAR or after the procedure until the CABG surgery, with a dual antiplatelet regimen continued afterward. Neurological examinations were conducted prior to TCAR, immediately postoperatively, and at specified intervals onward. A poststenting angiogram was often performed to confirm patent CCA and ICA as well as flow into the brain.

RESULTS

A total of 14 cases with staged TCAR prior to CABG were identified from a systematic chart review (Table I). Nine patients (64.3%) were male. The median age was 64.5 (IQR 14.75) years, and the median BMI was 25.1 (IQR 11.5). Hypertension was the most frequent documented risk factor with 13 of 14 patients having a history of hypertension (one patient's hypertensive history was unknown). Eight of 14 patients had a history of smoking greater than 10 pack years, 8 of 14 patients had a history of diabetes mellitus, and 2 of 14 patients had prior TIA or stroke-like events. Nine of 14 patients had a right-sided TCAR, while 5 of 14 had a left-sided TCAR.

TCAR was recommended in patients with high stroke risk prior to CABG based on neurological symptoms, percentage of stenosis, occlusion of contralateral vessels, or high-risk plaques. Four patients (28.6%) presented with symptomatic stenosis more than 50% and four patients (28.6%) presented with asymptomatic stenosis greater than 70%. Three patients (21.4%) were delineated as 'high-risk of stroke' based on radiographic evidence of soft or mobile carotid plaque or occlusion of contralateral cerebral arteries.

All patients were evaluated for transcarotid revascularization in the setting of CAS identified prior to CABG (Table II). Twelve of 14 patients had a blood loss amount of less than 100 mL during their TCAR (Table III). All TCAR procedures were performed under local anesthesia such as lidocaine or bupivacaine with minimal sedation. All patients underwent TCAR without any postoperative neurologic deficits or postoperative strokes. Four patients (28.6%) underwent double bypass surgery, 6 patients (42.8%) underwent triple bypass surgery, and four patients (28.6%) underwent quadruple

Table I. Patient demographics of study cohort

Study cohort demographics (n = 14)	
Age (median, IQR)	64.5, 14.75
body mass index (median, IQR)	25.1, 11.5
Gender	
Female	5 (35.7%)
Male	9 (64.3%)
Ethnicity	
Hispanic/Latino	1 (7.1%)
Not Hispanic/Latino	13 (92.9%)
Race	
White	10 (71.4%)
Black/African American	2 (14.3%)
Asian	1 (7.1%)
Other	1 (7.1%)

IQR = interquartile range.

bypass surgery. The median time between TCAR and CABG was 4 days with 9 of 14 patients (64.3%) having an interval time of less than 1 week.

All patients had fully intact neurological exams postoperatively with no change in status for the remainder of their hospital stay. Of our 14 patients, no MACE events were reported including TIA, stroke, MI, or TCAR-related death in the interval between their TCAR and CABG as well as in a 6-month follow-up period (Table IV). One patient required to return to the OR for evacuation of a neck hematoma. One patient reported hoarseness for 6 weeks post-TCAR-CABG that resolved spontaneously.

Table II. Medical history and carotid disease characteristics of study cohort

Study cohort characteristics	
Past medical history	
Hypertension	13 (92.9%)
Smoking history	8 (57.1%)
Diabetes mellitus	8 (57.1)
History of TIA[a] or Stroke event	2 (14.3%)
Indications for TCAR[b]	
Symptomatic stenosis >50%	4
Asymptomatic stenosis >70%	6
Laterality of TCAR	
Right sided	9 (64.3%)
Left-sided	5 (35.7%)
Cardiac intervention	
CABGx2	4 (28.6%)
CABGx3	6 (42.8%)
CABGx4	4 (28.6%)
Postbypass ejection fraction	
≤45%	2 (15.4%)
>45%	11 (84.6%)
Time between TCAR and CABG[c]	
<1 week	9 (64.3%)
1−3 weeks	1 (7.1 %)
>3 weeks	4 (28.6%)
Median (days)	4

[a]Transient Ischemic Attack-TIA.
[b]Transcarotid Artery Revascularization-TCAR.
[c]Coronary Artery Bypass Grafting-CABG.

DISCUSSION

Atherosclerosis is a systemic disease that often involves both the coronary arterial system as well as carotid arteries. Treatment of this disease can be performed with a staged-TCAR-CABG intervention and has been previously described in the literature. However, there is currently no standard guideline for deciding optimal anesthetic care for carotid revascularization procedures prior to CABG and lack of studies assessing the cardiovascular outcomes of patients who receive TCAR prior to CABG under local anesthesia. Considering the numerous anesthetic challenges of patients with cardiac comorbidities, local anesthesia should be prioritized as an anesthetic choice to reduce perioperative morbidity in this population of high-risk patients.

This report describes postoperative outcomes of TCAR under local anesthesia performed in a staged fashion prior to CABG surgery. TCAR remains an alternative carotid revascularization suggested for patients who have high surgical risk for CEA. Dermody et al. defined high surgical risk patients as patients with prior ipsilateral CEA, neck dissection, neck radiation, cranial nerve injury, severe chronic obstructive pulmonary disease, and unrevascularized CAD.[13] By using the ENROUTE Transcarotid Neuroprotection System, the TCAR procedure attains reversal of blood flow and minimizes plaque or embolic debris from traveling to the brain. Direct transcervical carotid access also eliminates the risks associated with arch manipulation.[14] Systematic literature review demonstrates comparative outcomes of TCAR compared to CEA with regards to technical success rate, perioperative stroke and TIA incidence, and mortality rates.[14]

However, the risks and recommendations of anesthetic choice in the setting of a staged-TCAR-CABG remain undescribed in current scientific literature. Ankam et al. describe the use of either general anesthesia, regional anesthesia, or monitored anesthesia care for a TCAR procedure alone.[15] While general anesthesia can provide tight ventilatory control and potentially reduce stress for both the patient and surgeon, regional anesthesia or monitored anesthesia care allows for precise neurological

Table III. Intraoperative parameters for TCAR and CABG procedures

Intraoperative parameters	
Anesthesia Type for TCAR	
Local anesthesia with minimal sedation	14 (100%)
Blood loss during TCAR	
<50 mL	5 (35.7%)
50−100 mL	7 (50%)
>100 mL	2 (14.3%)
Products given during CABG	
Cell saver (mL)	
0	1 (7.7%)
<250	1 (7.7%)
250−500	5 (38.5%)
>500	6 (46.1%)
PRBC[a] (units)	
0	7 (53.8%)
1−2	4 (30.8%)
6	2 (15.4%)
Autologous (mL)	
0	5 (38.5)
100−600	5 (38.5%)
>600	3 (23%)
Platelets (units)	
0	4 (30.8%)
1	7 (53.8%)
>1	2 (15.4%)
FFP[b] (units)	
0	10 (76.9%)
1−2	1 (7.7%)
3−4	2 (15.4%)
Cryoprecipitate (units)	
0	9 (69.2%)
1	2 (15.4%)
2	2 (15.4%)
Factor VII (mg)	
Did not receive	12 (92.3%)
Received	1 (7.7%)
DDAVP[c] (mcg)	
Did not receive	4 (30.8%)
Received	9 (69.2%)

[a]Packed red blood cells-PRBC.
[b]Fresh frozen plasma-FFP.
[c]Desmopressin (1-deamino-8-D-arginine vasopressin)-DDAVP.

monitoring of the patient who were awake during carotid clamping and less cardiovascular distress.[15,16] The Carotid Revascularization Endarterectomy versus Stent Trial studies observed an increased (two-fold) risk of cardiac complications, including periprocedural stroke and death, in patients undergoing CEA with general anesthetic compared to those undergoing CEA with regional anesthetic.[17] Ankam et al. describe the gold standard for neuromonitoring to be intraoperative neurological evaluation—which can be accomplished by local anesthetic.[15]

Table IV. Postoperative complications in staged-TCAR-CABG patients in 6 months

Type of complication	*n* (%)
Stroke incidence	0 (0%)
Myocardial infarction	0 (0%)
Neck hematoma	1 (7.1%)
Wound infection	0 (0%)
Hypophonia	1 (7.1%)

The findings of this study showed no cardiac or neurological complications following TCAR under local anesthesia with a minimal level of sedation in patients with advanced multivessel CAD. This data supports the use of a staged-TCAR-CABG approach with the substantial benefit of local anesthetic use to minimize cardiac morbidity and complications. The ability to immediately evaluate the neurological status of patients is imperative in monitoring for intraoperative strokes during the TCAR as well as in the postoperative period. Given the clinically unremarkable 6-month follow-up periods of these patients, there is evidence of minimal vascular deterioration associated with this protocol.

Overall, this study demonstrated the safety of using local anesthetic in TCAR among patients who underwent staged-TCAR-CABG surgery. The primary limitation in this study was the small sample size in a retrospective, single-center study. A larger multicenter study is needed for more thorough and statistically significant assessment of employing local anesthetic in TCAR among patients who undergo staged-TCAR-CABG surgery.

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