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» TCAR

TOWARD THE **STANDARD OF CARE** FOR CAROTID REVASCULARIZATION

TCAR (Transcarotid Artery Revascularization): The Next Step in the Evolution of Carotid Revascularization

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Since its introduction in the 1950s, carotid endarterectomy (CEA) has been considered the gold standard treatment option for carotid revascularization. However, in patients with high-risk anatomic and/or physiologic characteristics, CEA is associated with higher rates of adverse outcomes.[1] Transfemoral carotid angioplasty and stenting (TF-CAS) was introduced over 2 decades ago as a potential alternative. However, its effectiveness compared to CEA remains unclear, and full adoption of TF-CAS has been hindered by a higher rate of periprocedural stroke.[2]

Transcarotid artery revascularization (TCAR) was first introduced in the United States in 2012. TCAR is a surgically inspired procedure based upon concepts developed by vascular surgeons Enrique Criado, MD, and David Chang, MD. The technique combines direct carotid artery access and robust reversal of flow during transcarotid stent placement to provide CEA-like neuroprotection in a less-invasive approach.[3] TCAR minimizes the potential for cerebral embolization by eliminating the need for aortic arch manipulation and unprotected lesion manipulation with the distal embolic protection deployment necessary in TF-CAS. Results from the prospective ROADSTER clinical trial demonstrated a periprocedural stroke rate of 1.4% for TCAR in high-risk patients.[4] This represents the lowest reported stroke rate for any prospective multicenter trial of carotid stenting. With the result of this study, TCAR received FDA approval in 2015. Since then, additional data from the ROADSTER 2 trial (a postmarket study), large multi-institutional series, as well as real-world data from the TCAR Surveillance Project (TSP) continue to show that the results of TCAR are similar to CEA despite being performed in sicker, more frail, and high-risk patients.[5-7] Furthermore, the minimally invasive TCAR can be safely performed without the use of general anesthesia and is associated with shorter hospital stays and lower rates of cranial nerve injury.

As the global TCAR experience continues to increase, there has been additional insight into best practices to further enhance clinical results and maximize patient benefit. In this supplement, the reader will find a roundtable expert panel discussion on the optimal medical regimen for TCAR patients, with a focus on the ideal antiplatelet regimen, management of periprocedural antithrombotic therapy, and the importance of statin therapy. This is followed by a summary on the periprocedural hemodynamic management during TCAR to ensure robust flow reversal and avoidance of postprocedural adverse events. Finally, interviews with Drs. Jacques and Schermerhorn will address reimbursement and coverage for TCAR as well as the future research efforts of the TSP.

The growing body of evidence clearly shows that TCAR is a safe, more efficient, and patient-friendly procedure. As you adopt TCAR as a viable alternative to CEA in your patients with carotid artery occlusive disease, the authors that contributed to this supplement hope that you find the following articles valuable in your clinical practice. ■

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4. Kwolek CJ, Jaff MR, Leal JI, et al. Results of the ROADSTER multicenter trial of transcarotid stenting with dynamic flow reversal. J Vasc Surg. 2015;62:1227-1234.
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7. Kashyap VS, King AH, Foteh MI, et al. A multi-institutional analysis of contemporary outcomes after transcarotid artery revascularization versus carotid endarterectomy. J Vasc Surg. 2018;67:e191-192.

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Optimal Pharmacologic Strategy for TCAR: An Expert Panel Discussion

With many questions about the management of patients undergoing transcarotid artery revascularization (TCAR) left unanswered, a multispecialty panel of carotid experts gathered to provide guidance on the optimal medical regimen for surgeons who perform TCAR procedures. Recognizing that other important components of the topic were beyond the scope of the conversation, the specialists addressed optimal antiplatelet regimen, clopidogrel resistance, bridging/management strategy for TCAR patients requiring chronic oral anticoagulation, heparin-induced thrombocytopenia (HIT), and the use of statins before and after TCAR.

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OPTIMAL ANTIPLATELET REGIMEN FOR TCAR

The panel found a consensus that the optimal antiplatelet regimen surrounding TCAR is aspirin and clopidogrel (Plavix, Bristol-Myers Squibb Company and Sanofi).

Although platelet function testing to confirm patient compliance may have merit, literature suggests that there is no clear answer on the routine use of clopidogrel testing. Loading the patient with the appropriate doses of antiplatelet agents in the appropriate time frame or delaying the procedure, assuming it is a standard nonemergent case, are both viable options.

It was recognized by all that clopidogrel (Plavix) resistance is a common phenomenon; however, it is unclear why the issue has not resulted in greater rates of thromboembolic complications to patients undergoing carotid stenting.

Dipyridamole (Persantine, Boehringer Ingelheim Pharmaceuticals, Inc.) was confirmed to have no role in this procedure. However, if a patient is in on cilostazol (Pletal, Otsuka America Pharmaceutical Co.), they may stay on cilostazol (Pletal), understanding that cilostazol (Pletal) is not a substitute for clopidogrel (Plavix) or other P2Y12 inhibitors such as ticagrelor (Brilinta, AstraZeneca) or prasugrel (Effient, Eli Lilly and Company).

Dr. Macdonald: We had a 5% major protocol deviation rate in ROADSTER 1, and in the majority of cases, it was a violation of the drug regimen. It is mandatory that patients are on a statin and dual antiplatelet therapy (DAPT) for the trials. Patients who deviate from the protocol are much more likely to have an adverse event within the trial. What do you think is the cause for this deviation from recommended medical therapy?

Dr. Cambria: In commercial experience, it is certainly in the realm of understanding for most vascular surgeons that a stent-based therapy, either transfemoral or even TCAR, will not commonly have a knee-jerk reaction or resistance related to periprocedural bleeding. There are papers from the vascular surgery VQI meeting that purport to show the safety of DAPT in carotid surgery. In the main body of vascular surgeons, I don't think there is resistance to this. Maybe it is inattention to detail on the part of a study coordinator.

Dr. Macdonald: There is definite potential for a major breakdown in communication around TCAR because it is not a percutaneous procedure.

Dr. Kokkosis: It's been a battle in our institution, because all our patients go through a preoperative assessment through nursing and anesthesia, and it's been their former practice to discontinue all antiplatelets for every specialty, every surgery. We sat down with the anesthesia department and multiple surgical specialties and made a guideline that essentially dictates, depending on specialty, when it is appropriate to stop the antiplatelet therapy. For vascular, we say never stop unless there are certain criteria. That has certainly improved the compliance with our patients and the staff.

Dr. Macdonald: Let's extrapolate what we know about the drug regimen for transfemoral stenting to TCAR, if we can. Is it moving toward more potent agents—prasugrel (Effient), ticagrelor (Brilinta)—routinely, as it has moved for percutaneous coronary intervention (PCI)?

Dr. Aronow: I believe it's fair to extrapolate as there should not be differences in the safety or effectiveness of antiplatelet therapy whether used for transfemoral carotid stenting, transradial carotid stenting, or TCAR. As with carotid stenting performed from other access sites, it would be difficult to construct an argument that supports more potent antiplatelet agents with TCAR; there is simply no level 1 evidence to support doing so.

Dr. Macdonald: What do you think about the bleeding risk on a more potent antiplatelet agent than clopidogrel (Plavix) for TCAR?

Dr. Cambria: Probably not a big consideration. I have performed a handful of carotid endarterectomies (CEAs) on patients whose cardiologists have said their ticagrelor (Brilinta) is really vital. I don't think that the more potent antiplatelet agents are necessary or desirable, so I wouldn't go there, even if I felt that the added bleeding risk was minimal.

PLATELET FUNCTION TESTING

Dr. Macdonald: Is routine platelet function testing necessary? If we have a test that is abnormal, how is that then managed?

Dr. Aronow: From a prognostic standpoint, antiplatelet function testing is interesting, but we don't know that we can change the prognosis based on this information. My fear is that we will not only increase cost by routinely measuring this parameter, but will introduce a lot of practice variability. We all may have different thresholds for when and how to act, and none of us know whether it is appropriate.

Dr. Jaff: I wholeheartedly agree, and I think there is an unintended consequence of doing this, given that the thromboembolic event rate appears to be so low with TCAR. If someone has an abnormal platelet aggregation test, the physician is going to feel obligated to do something about it, even though the data show that it won't impact the outcome. Either the cost will increase because you use a much more expensive parenteral agent, or they'll increase bleeding for absolutely no reason.

Dr. Guzman: I do routine thromboelastography (TEG) testing, and it comes from a twofold motivation. Number one is acknowledging the fallibility of us as clinicians and our teams in getting the instructions out and also that of the patients in following the instructions, whether from lack of understanding or lack of access to the medication. Second, while not data driven, you sometimes find yourself in a clinical situation you don't want to repeat.

The turning point for me was a man who complied with everything, and he had a minor stroke 12 hours in. Initially I thought he was microembolizing through the stent and cheese grating, and it occurred to me to test his platelet function. Lo and behold, on this test, he was not optimally inhibited. He was at ongoing risk for embolization, and that lack of antiplatelet action was part of the culprit, so I felt that I needed to act.

Dr. Macdonald: What are the differences between TEG testing and VerifyNow or other measures of platelet function that measure P2Y12 platelet receptor blockade?

Dr. Guzman: TEG testing, unlike the others, is a whole coagulation test, and it's a dynamic test that gives you several data points on the function of clotting factors and their inhibition, be it by heparin, warfarin (Coumadin, Bristol-Myers Squibb Company), or the novel drugs (direct oral anticoagulants such as apixaban [Eliquis, Bristol-Myers Squibb Company]). It gives you an idea of platelet function in conjunction with fibrin. It is measured by tracing; it looks a bit like a wine glass, and the maximum amplitude of that wine glass is the maximal clot strength, which is the function of platelet activity and fibrin available to bind the platelets together.

In its initial form, that simply tells you what the platelet and fibrin function is, but there is an ability to add agonists (arachidonic acid or adenosine diphosphate [ADP] to test the platelet function) so you have several curves indicating the effect of ADP inhibitors or aspirin.

Dr. Jaff: Should you test everybody before you do the procedure?

Dr. Kokkosis: I'm going to interject a little, because then you run into the debate of cost. In my area, there are certain insurance companies that won't cover the clopidogrel response assay.

Dr. Guzman: There are several aspects of cost. The most direct is, how much does this TEG test cost? If it is performed the day of surgery, it's going to fall within the diagnosis-related group of carotid artery stenting. The cost to the hospital for the test is about $100, so it's not a big dent in the reimbursement.

Second, there is always the cost of time. I rarely do TCARs first thing in the morning, so that I don't have to kill time waiting to get the TEG test results. TEG takes about 60 minutes to run beginning to end, but the maximal amplitude occurs at about 15 to 20 minutes. At that point, you could get the data you need.

Dr. Jaff: The question about cost-effectiveness is different than cost of the test. To say this would be a cost-effective strategy, you need to do this test on every patient who's eligible for a TCAR procedure and show that you will prevent X number of adverse events that would cost X thousands of dollars. You then would do the number needed to test to prevent one event. That's a big task to study, particularly given the relatively low number of these cases that are being performed.

CLOPIDOGREL RESISTANCE

Dr. Macdonald: When it comes to clopidogrel (Plavix) resistance, what is your rationale behind routine testing? Is it practical and feasible?

Dr. Aronow: Resistance is relatively common and it's of prognostic value, meaning that people who are resistant to clopidogrel (Plavix) have a worse outcome over time than people who are not. That said, I don't think we have convincing data that trying to do anything about it (either by using a higher dose or a more potent P2Y12 inhibitor) changes outcomes.

The GRAVITAS trial studied patients undergoing PCI who had high treatment platelet reactivity—patients resistant to clopidogrel (Plavix).[1] They randomized that cohort of patients after the procedure to a standard dose of 75 mg or 150 mg of clopidogrel (Plavix) once daily. Over time, the composite of death, myocardial infarction, or stent thrombosis was no different between the groups. Perhaps if the study had been larger, we would have seen what we've seen from many other studies: that people who have high on-treatment platelet reactivity have worse outcomes and are more likely to experience atherothrombotic events, but we can't change their prognosis by giving them a different dosing regimen.

Another trial looked at potency of P2Y12 agents, specifically clopidogrel (Plavix) and the more potent prasugrel (Effient), and not surprisingly, the more potent agents led to a greater reduction in platelet reactivity units (PRUs)—more inhibition of the platelets.[2]

A nonrandomized study of carotid artery stenting showed over time that if PRU is stratified (they used a cutoff of 198 in this instance), ischemic event-free survival and survival was worse in people who had higher reactivity.[3]

Dr. Macdonald: About what percentage of the general population do you think is resistant? I hear it's about 20%, and it may be higher in an Asian population. If that's the case, why aren't

we seeing more events in our patients who are undergoing TCAR? The stroke rate is very low.

Dr. Cambria: In my opinion, the big differential between the incidence of clopidogrel (Plavix) resistance and clinical events probably relates to the fact that there's been a lot of focus on DAPT. Unlike the coronary circulation, when you're talking about a large-bore or high-flow system like the internal carotid artery, you can do the operation without heparin (although heparin is recommended), so the protective or operative effect of the clopidogrel (Plavix) and/or aspirin in these patients probably has a very small delta.

There are long-standing retrospective studies that showed that periprocedural events were statistically better in patients with antiplatelet therapy, and that's why it's in the guidelines for CEA. However, I still think that the delta for a vessel of this size is probably very small and very different compared to a 2-mm stent in the coronary artery.

Dr. Aronow: Resistance is systemic, not confined to a particular vascular bed, so it's likely that estimates from patients with coronary disease are applicable to patients who have carotid disease. Because we are talking about events that occur infrequently after carotid stenting, even if they occured 25% or 50% more often, the difference may be very difficult to detect.

Dr. Jaff: I also think that given the wide spectrum of specialists who perform carotid stenting, I'm not sure how prevalent their knowledge is about clopidogrel (Plavix) resistance. I certainly don't think they know how to test it, because it is not readily available in many places for certain specialties, so we may be seeing events that have been ascribed to other reasons.

Dr. Macdonald: That's a good point. The multisociety guidelines, as well as the vascular surgery guidelines, state quite clearly that DAPT is strongly recommended in the setting of carotid stenting. We believe that it takes about a month for a bare-metal stent to endothelialize, so the recommendations are supportive of the DAPT regimen and statins. If you look at the wording of the recommendations, they promote the use of statins to reduce the low-density lipoprotein (LDL) to a certain level. Perhaps more important are the pleiotropic effects of statins—effects beyond those for which the drug was formulated, such as plaque stabilization and immunomodulatory effects. Ezetemibe (Zetia, Merck & Co., Inc.) and bile acid sequestrants such as cholestyramine (Questran, Par Pharmaceutical Companies, Inc.) might manage the lipid profile abnormalities but do not stabilize plaque and thus do not reduce embolic potential of the carotid lesion like statins.

ROLE OF OTHER AGENTS IN TCAR

Dr. Jaff: What is the role of dipyridamole (Persantine) in patients undergoing TCAR?

Dr. Cambria: I would never use it.

Dr. Aronow: For periprocedural management of carotid stenting? No.

Dr. Jaff: There is an interesting body of literature about cilostazol (Pletal) preventing in-stent restenosis in various vascular beds, including carotid stents. From the periprocedural standpoint, if a patient comes to you in need of a TCAR procedure who is on cilostazol (Pletal) for claudication, would you stop it?

Dr. Aranson: No, I would not stop it, but I would use it additively. I would not substitute cilostazol (Pletal) for clopidogrel (Plavix), but I would use aspirin, cilostazol (Pletal), and clopidogrel (Plavix) with no problem. There are some data in the PCI literature showing that triple therapy decreased perioperative or periprocedural events. Overall, I think that the majority of the data on using cilostazol (Pletal) additively supports that it is not damaging or deleterious in any way.

Dr. Guzman: Agreed.

Dr. Kokkosis: Agreed.

Dr. Cambria: Agreed, because the bleeding concern for a TCAR cutdown is all that much diminished compared to even a standard CEA.

Dr. Aronow: I don't know if there's enough evidence in the literature to suggest that the bleeding risk is higher when someone is on cilostazol (Pletal) plus DAPT. There is no doubt that the bleeding times and degree of platelet inhibition are impacted, but I don't know whether this translates into clinical harm. If we had good evidence that it did, it would be reasonable to recommend holding it temporarily.

BRIDGING/MANAGEMENT STRATEGY FOR PATIENTS ON CHRONIC ORAL ANTICOAGULANT

The discussion surrounding how to manage the patient on chronic oral anticoagulant therapy consisted of many depending variables, and a nuanced review is necessary while making treatment decisions. Management depends on what oral

anticoagulant the patient is on, the viewed risk of thromboembolic events, and whether the patient should stop those agents acutely. What is the patient's true inherent bleeding risk—not necessarily from the incision, which the panel strongly confirmed is not a significant bleeding risk—but systemic bleeding? If a patient who needs to go back on an oral anticoagulant then needs to be on DAPT within 1 month of the TCAR procedure, the risk of systemic bleeding becomes more important.

Dr. Macdonald: How may the management of a TCAR patient be influenced by the CHADS2 scoring system that we use in atrial fibrillation (AF) patients to assess their baseline risk for stroke? Do you think this is a tool that's well recognized in the vascular surgery community?

Dr. Cambria: I think that most vascular surgeons, myself included, know that there is something called a CHADS2 score, but if you ask them to delineate the elements of it, they wouldn't know and they would defer that decision to the patient's cardiologist.

Dr. Jaff: There are patients who have low CHADS2 scores and patients who have high CHADS2 scores, so your management of their anticoagulation around the time of the procedure will vary widely. Someone may be taking direct-acting oral anticoagulants for AF, so you just skip one dose and do their procedure. But another patient may need to be put on low-molecular-weight heparin 5 days before the procedure and start heparin intravenously the night before. There is real clinical relevance to this tool.

Dr. Aronow: Absolutely, and the decision is not necessarily intuitive on the surface. We must consider several factors when evaluating whether, when, or how to stop an anticoagulant and when to restart it. There is the risk of the procedure, but also the patient's bleeding and thrombosis risk.

There is a recent expert consensus document that came out of the American College of Cardiology about what to do with anticoagulation. For the CHADS2 category 1 to 4 score patients, they're considered low thrombotic risk. It's the moderate- to high-risk patients where it becomes a little more of a conundrum. The BRIDGE randomized trial of patients who were primarily in the 1 to 4 range did not find that there was a significant reduction in ischemic events; it found that bridging was noninferior when it came to arterial thromboembolism, and there was more bleeding with the bridging strategy.[4] There is clear evidence that you're going to make people bleed more if you bridge them, and no clear evidence that there is any difference preventing thromboembolism, which is what we're most concerned about.

Dr. Macdonald: What is your experience with bridging versus nonbridging?

Dr. Aranson: I've had two patients with AF who had adverse events postprocedurally. One was about 5 days out and one was about 2 weeks out, both with cardioembolic events in the postoperative setting while on therapeutic anticoagulation—vitamin K antagonists with an international normalized ratio (INR) > 2. Reviewing the literature, it doesn't seem like I am doing anything wrong, but what are the practice patterns nationwide? When I travel to proctor other individuals, I ask about their approach to patients with AF and their postprocedural management. Some folks will opt for vitamin K antagonists as well as DAPT. Some neurologists I've spoken to have said that's too much, and it can increase bleeding intracerebrally and extracranially.

There are also considerations by other physicians as to whether or not DAPT in the postoperative setting alone without anticoagulation or vitamin K antagonists is appropriate for those 4 weeks. Some literature supports DAPT in the setting of AF for that month does have reduction of stroke risk, although not as potent as vitamin K antagonist use.

The other question is, is this just bad luck? The stroke risk for these patients 1 month after the procedure should be < 1%.

Dr. Macdonald: For a patient who requires heparin bridging for whatever reason (eg, high CHADS2 score with AF), when would you feel comfortable putting that patient back on warfarin (Coumadin) and stopping DAPT? Would you continue with one antiplatelet going forward?

Dr. Aronow: Those are tough questions and I don't think anybody knows the answer. I don't think there is solid evidence. We can extrapolate a little bit from some of the coronary intervention literature. The WOEST trial randomized patients who received coronary stents to DAPT plus warfarin (Coumadin) or clopidogrel (Plavix), and warfarin (Coumadin) where they dropped the aspirin.[5] Not surprisingly, there was more bleeding with triple therapy, but there were not fewer ischemic events. The people who were only on two agents (warfarin [Coumadin] and the clopidogrel [Plavix]) did better, from an ischemic standpoint.

One option is to restart the warfarin (Coumadin) on the day of the procedure, and give clopidogrel (Plavix) but not aspirin. However, I don't believe there are any data to support that approach.

Dr. Kokkosis: I absolutely agree with you because in practice, based on those trials and in discussion with

cardiologists and neurologists who comanage the patients, that's what we've done with clopidogrel (Plavix) and an anticoagulant.

Dr. Macdonald: Dr. Aranson, you were instrumental in starting the TCAR program at Virginia Mason. How did you go about addressing the requirement for the DAPT regimen?

Dr. Aranson: We had some of the same difficulties that Dr. Kokkosis has mentioned, and that relies on the anesthesiologist, preoperative nursing staff, and my own clinical assistants all being on the same page with respect to the DAPT requirements.

When I have decided on TCAR for a patient, I will give them the prescription and written instruction on their medications for the 7 days prior to the procedure so that they are not confused. Oftentimes, these are patients who are taking 10 other medications and adding even one more that sounds like another medication they're on is quite confusing. We follow-up with the patient the day before the operation to ensure that they've been taking their DAPT. That allows a fail-safe mechanism, because if they have not, we still have the option to load them, per the guidelines, during the following day.

Dr. Macdonald: How do you think these hands-on best practices that Drs. Aranson and Kokkosis are describing here can be generalized in such a way that it's not so labor intensive for TCAR practitioners?

Dr. Cambria: It gets down to the weeds of the individual practice. Over the years, I fought the things that Dr. Kokkosis did with preadmission testing. Now, education actually does happen, and it ultimately became part of the surgical coordinating committee policy that patients on aspirin for cardiovascular disease never stop their aspirin unless there is some particular individual consideration. I also am in the practice of having my anesthesia staff and fellows clearly ask for and document whether the patient took their antiplatelet medications that morning. A paper in hand to the patient on instructions, in particular with DAPT, might be a handy thing.

Dr. Kokkosis: I'd also add that the compliance of the DAPT and statin therapy hinges on the local landscape. In some areas, there's a very close relationship between my patients and their cardiologist or their primary care doctor. So, the best way I can ensure compliance is by reaching out to their doctor, whether it's a phone call, visiting them in the office, or giving grand rounds to the primary care doctors. Often, even in our advanced technologic age of communication, we don't communicate enough. The patient and referring physicians need to be educated on the right drugs.

PRESCRIBING STATINS BEFORE AND AFTER TCAR

It was supported that ideally, all patients undergoing TCAR should be on high-dose statins. There was interest in the potential for some novel agents to help with plaque stabilization and major adverse events and death, including monoclonal antibody and PCSK9 monoclonal antibody inhibitors.

Dr. Jaff: There is a huge amount of misunderstanding about statin intolerance. If a patient played a very physical game of tennis the day before an appointment, and then their doctor starts them on a statin and they get muscle aches the next day, they'll be told that they have statin-related myalgia and can't take statins anymore. It seems people are labeled with statin intolerance, which may be really detrimental.

The benefits of a statin extend far beyond the TCAR procedure. I don't think anybody, even the most reluctant of people, would argue that statins reduce the risk of cardiovascular death, period.

Dr. Aronow: I agree. I think the evidence suggests that you will reduce both long-term risk and procedural risk by starting a statin up front.

Dr. Kokkosis: One of the most important effects of statins that patients understand is that it's an anti-inflammatory. A lot of patients buy a lot of medications and herbal supplements based on the anti-inflammatory properties because it's all over TV and commercials. It amazes me when a patient comes to me and says they are "allergic to the statin and don't want to take it because it's bad for you and destroys the liver." But I tell them it's a really good anti-inflammatory, and then the conversation opens and they understand.

Dr. Aronow: These conversations are occurring periprocedurally and on a day-to-day basis. Patients often read the statin labels' long list of side effects, and it doesn't take much for a patient to decide, "this agent isn't for me."

There's a long- and a short-term issue here. In the short term, you want to do your best to get that patient on the statin before the procedure, at least in the periprocedural phase. Longer term, it might need to be a team effort with you, the primary care physician, and the patient deciding on the best course.

Dr. Macdonald: We've also had a handful of questions about bile acid sequestrants (Questran) or ezetimibe in place of a statin.

Dr. Aronow: No matter how you decrease LDL (diet, ezetimibe, bile acid sequestrant, or a statin), we know it ends up being beneficial from the standpoint of reducing future cardiovascular events. If somebody is not going to be on a statin, then I think it's reasonable to try to get them on another agent to reduce events—although we know that you can't reduce events to the same extent as you can with statins.

Whether there is any benefit periprocedurally, I don't think we know. There isn't anything in the literature about ezetimibe or bile acid sequestrants and carotid stenting.

Dr. Jaff: The literature on the benefits of bile acid sequestrants on plaque regression are dated, and they're used largely when you're out of other options. They're important therapies in patients with lipid abnormalities but should not be considered during the evaluation for TCAR.

HIT

HIT is a very serious disorder. If a patient has a documented history of HIT, with or without thrombosis, they cannot be managed with heparin of any type. The alternates are bivalirudin (Angiomax, The Medicines Company) or argatroban (Argatroban, Pfizer Inc.), and the panelists were all comfortable using either as a parenteral anticoagulant during the procedure if needed.

Dr. Macdonald: For patients who can't take heparin, what are your thoughts about bivalirudin (Angiomax) in terms of the potential bleeding?

Dr. Aronow: There are no published randomized data on this issue. There was a trial a couple of years ago that attempted to look at this question by including patients who were undergoing carotid stenting along with those who were undergoing lower extremity revascularization for claudication or critical limb ischemia, but it was terminated prematurely.

In a PVI registry study, we looked at patients who underwent carotid stenting. We matched them on the likelihood of receiving unfractionated heparin or bivalirudin (Angiomax) as their procedural anticoagulant, and we did not see any significant difference for most outcomes.[6] There was a lower incidence of bleeding or hematoma that required red cell transfusion with bivalirudin (Angiomax), but everything else looked the same. Absent randomized data, bivalirudin (Angiomax) seems like a reasonable option for patients who are going to undergo percutaneous access.

If you are undergoing a surgical cutdown, it's a completely different conversation. I would defer to my surgical colleagues, but it would seem to me that because it's not a reversible agent that you would want to try to avoid it.

Dr. Guzman: I have not performed TCAR on a bivalirudin (Angiomax) patient, but my concern is that bivalirudin (Angiomax) is partially degraded in the bloodstream. I recall when we used it for lower extremity cases, the recommended practice was to flush bivalirudin (Angiomax) periodically to avoid it degrading in the leg and clotting while you have no flow. What do you do with that static column of blood in the common carotid artery beneath your clamp? I don't have an answer to that. I would probably be meticulous about flushing that out and perhaps even make a little arteriotomy to ensure there was no residual thrombus. I would feel more comfortable doing an open carotid under bivalirudin (Angiomax) than doing a TCAR.

Dr. Cambria: Argatroban is what I've used for that circumstance, so I don't really have any experience with bivalirudin (Angiomax). Should that decision be dependent on a current HIT assay? As you know, there are patients who had an episode, were positive 4 years ago, and now they're tested and someone declares that heparin is perfectly safe. What do you think about the timing of a current up-front HIT assay as part of that assessment?

Dr. Jaff: In that scenario, hematologists should be consulted. That is a dangerous call to make and a very high-risk situation if not managed appropriately. Have a team around you that you can count on to help you manage.

Dr. Macdonald: Our recommendation to the field is that if you have a complex case regarding either heparin bridging requirements or the management of a patient with HIT, have a conversation with the cardiologist or hematologist who is managing the patient.

Dr. Jaff: When do you turn over the patient's atherosclerotic risk factor management to the primary care doctor? Diabetes, of course, is one of the most important atherosclerotic risk factors, along with tobacco cessation, but those are beyond the scope of this manuscript.

Dr. Guzman: We tend to own the problem going forward. For the most part, we follow them at 6-month and then yearly intervals. At every visit, there is a quick check of their medication list to see if they're still taking what we want them to be on. If not, we take that opportunity to renew.

Dr. Jaff: What do you do if their blood pressure is high in your office? Do you also ask them to bring their latest lipid profile?

Dr. Guzman: In terms of the lipids, I simply make sure that they're on high-intensity statin therapy. Several policies have been implemented regarding blood pressure in our institution, the most recent of which is a very thorough standardization of blood pressure measurement protocol and equipment across the organization. If any provider identifies a blood pressure outside of recommended guidelines, they have the power to automatically make an appointment with a primary care doctor within 2 weeks. Blood pressure management goes back to the primary care doctor automatically.

Dr. Kokkosis: In our practice we're fortunate to be close with the referring doctors, so oftentimes if we initiate it, they'll continue it, but I do diligently follow-up with the patients at 3, 6, 12 months, and every year, and we always check the medications to make sure they are still on the appropriate regimen.

We always check patients' blood pressure when they come in and make a point to discuss it with them if it's out of range and make sure that they follow-up with their primary care doctor.

Dr. Aranson: Oftentimes, these patients have some transient hypotension after their TCAR procedure. I hesitate to send them home on their full spectrum of antihypertensives if they are also hypotensive because, as we know, even transient hypotension can lead to stent thrombosis and adverse events. I'll communicate directly with the patient and the primary care physicians or the cardiologist about holding medications even temporarily.

Dr. Cambria: I send my TCAR patients home on the same outpatient surveillance that I send with CEAs: a daily visit by a Visiting Nurse Association practitioner for a week after carotid surgery to check blood pressure and symptoms. The blood pressure that is taken in a surgeon's office is often out of whack.

There's a lot of difference of opinion about holding angiotensin-converting enzyme inhibitors before carotid surgery. The paradigm of TCAR takes the concern of the baroreceptors and the carotid sinus nerve out of the equation, as there is a local force on the carotid baroreceptors exerted by the stent, which will continue to expand for a period of time, so I'm not sure why there should be that effect on blood pressure. I would expect if it were studied, there would be much less fluctuating blood pressure with TCAR than with a standard CEA.

Dr. Aronow: Even as a cardiologist, there's still a need to comanage with the primary care physician, who sees the patient more frequently.

My personal style with blood pressure is to have them keep a log for a week with a blood pressure cuff they can use at home and bring me the data. I don't want to make a change based on that one narrow window of time in my office, because they probably just rushed into the office or they may be anxious, so their blood pressure is higher.

CONCLUSION

Dr. Jaff: Based on presented literature and practice experience, the panel agreed that the optimal antiplatelet regimen is aspirin and clopidogrel (Plavix). Although clopidogrel (Plavix) resistance is a common phenomenon, it has not substantially impacted carotid stenting outcomes. There are some who believe that platelet function testing is an excellent way to assess medication compliance before the procedure; one practice does this routinely and there may be benefit to this, but further studies are needed. All panelists supported that patients who will be undergoing TCAR should ideally be on high-dose statins. There is interest in the potential for some novel agents (PCSK9 monoclonal antibody inhibitors) that help with plaque stabilization, major adverse events, and death. ■

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Periprocedural Hemodynamic Management for Transcarotid Artery Revascularization

Adequate blood pressure regulation is crucial for maintaining flow reversal and neuroprotection.

BY MICHAEL R. JAFF, DO; ANGELA A. KOKKOSIS, MD; JOSÉ IGNACIO LEAL, MD, PHD; AND SUMAIRA MACDONALD, MBCHB (COMM), MD, FRCP, FRCR, PHD

The carotid baroreceptors regulate blood pressure (BP) and heart rate (HR) in response to the pressure on the arterial wall by altering sympathetic and parasympathetic activity.[1] It has been suggested that this baroreflex is dysfunctional in the setting of chronic illnesses such as hypertension, coronary artery disease, carotid artery disease, diabetes mellitus, as well as advanced age.[2] Throughout the literature, the general consensus on the definitions of hypotension, hypertension, and bradycardia in the perioperative period of a carotid revascularization is: < 100 mm Hg, > 160 mm Hg, and < 60 bpm, respectively.[1-8] However, the use of mean arterial pressure and its clinical correlations during carotid surgery is not well documented.

In the setting of carotid endarterectomy (CEA), the baroreceptor sensitivity is diminished with the surgical disruption and removal of the nerve endings, resulting in hemodynamic instability (hypotension or hypertension and bradycardia) in up to 55% of patients.[3-5] This hemodynamic instability may last hours to days.[6]

On the contrary, in the setting of carotid artery stenting (CAS), hypotension and bradycardia have been observed in up to 76% of patients, secondary to stimulation of the carotid body receptors from the angioplasty balloon and/or stent placement.[7] In CAS, hypotension and/or bradycardia may last 12 to 24 hours.[8] True hemodynamic instability was seen in 39.4% of CAS patients, and instability lasting > 1 hour was seen in 19.2% of cases.[9] These patients were at higher risk for postoperative cerebrovascular and cardiac ischemic events.[1-8]

Many studies have investigated the risk factors for hemodynamic instability after CAS including > 70% stenosis, severely calcified plaque, bilateral stenting, balloon dilation pressure > 8 atm, overlapping stents, symptomatic carotid disease, and intraprocedural hypotension.[7,10-12] One factor that has been shown to be protective against bradycardia and hypotension is previous CEA.[7]

Transcarotid artery revascularization (TCAR) offers a unique hybrid approach with direct access to the common carotid artery in the neck that avoids the navigation of the aortic arch as in transfemoral CAS, but also avoids surgical dissection of the carotid bifurcation, as in CEA. This carries the potential benefit of minimizing the number of events of labile BP or HR. However, appropriate BP control is essential to maintain robust flow reversal and neuroprotection.

INTRAPROCEDURE

Intraprocedural hemodynamic instability has been shown to be an important predictor of postprocedural hemodynamic complications. Most of the hemodynamic instability events during and after stenting are transient and self-limiting, with most patients experiencing transient bradycardia with or without asystole that resolves after balloon deflation and intravenous administration of glycopyrrolate or atropine. Administration of prophylactic atropine (0.5 mg intravenously) before balloon inflation during CAS decreases the incidence of intraoperative bradycardia and cardiac morbidity in primary CAS patients.[7] Periprocedural bradycardia, hypotension, and the need for vasopressors occur more frequently with primary CAS than with repeat CAS procedures. With a similar action on acetylcholine receptors, glycopyrrolate (0.4 mg intravenously) has a shorter duration of action and more predictable course than atropine. Furthermore, glycopyrrolate possesses a superior adverse effect profile with a markedly lower incidence of cardiac morbidity following its administration than observed following atropine.[13,14]

TCAR offers the advantage of neuroprotection with flow reversal before crossing the carotid atherosclerotic lesion. Flow reversal is based on the difference between the arterial BP in the common carotid artery and the common femoral vein. Keeping a constant systolic BP between 140 and 160 mm Hg is crucial to achieve

robust flow reversal for neuroprotection by recruiting oxygenated blood flow across the circle of Willis and other collateral pathways.

POSTPROCEDURE

BP management is a key component in the postoperative period with any carotid intervention. Strict monitoring with an indwelling arterial hemodynamic catheter is mandatory because hypertension or hypotension may lead to significant complications such as cerebral hyperperfusion syndrome (CHS) or watershed infarcts.

Hypertension

Maintaining systolic BP < 160 mm Hg or within 20% of the preprocedure value is recommended. It is mandatory to treat perioperative hypertension in a controlled and titrated manner using short-acting antihypertensive drugs. Data from literature comparing the efficacy among antihypertensive agents after carotid artery surgery are scarce. In addition, the wide variability of responses in patients makes it difficult to predict the most efficient drug. The efficacy of α- and β-blocking agents, such as labetalol and esmolol, have been shown to be suitable for the treatment of perioperative hypertension. Typical dosing for esmolol for rapid BP control includes an initial bolus of 1 mg/kg, followed by an infusion of 0.15–0.3 mg/kg/min titrated to the systolic BP. For gradual postprocedure control, an initial bolus of 0.5 mg/kg is followed by an infusion starting at 0.05 mg/kg/min that is titrated based on systolic BP. These agents have no cerebral vasodilatory effects and do not influence intracranial pressure.

Hypotension

Persistent hemodynamic instability (defined as hypotension; systolic BP ≤ 90 mm Hg) lasting for > 1 hour and requiring vasopressor therapy is present in 19.2% of patients undergoing CAS.[9] The implication of sustained or sudden hypotension is an increased risk for periprocedural major cardiac events and stroke.[1-8,14] To help prevent this occurrence, intravenous hydration, use of glycopyrrolate or atropine, and use of vasopressors is recommended. An algorithm for the management of periprocedural hypotension during CAS has been published.[14]

CEREBRAL HYPERPERFUSION SYNDROME

CHS constitutes an infrequent but devastating complication after CEA and CAS. First described in 1981 by Sundt et al, it is defined as a clinical triad that includes ipsilateral headache, transient focal seizures and intracranial hemorrhage (ICH).[15] The combination of hypoperfusion associated with a significant carotid stenosis, with impaired brain reserve due to inadequate collaterals leads to compensatory dilatation of the distal cerebral vasculature as part of the cerebral autoregulatory mechanism. Once the carotid stenosis is treated, there is loss of autoregulation with associated hyperperfusion in previously underperfused areas. The capillaries are then more prone to rupture, culminating in hemorrhagic infarct.

Data comparing postoperative CHS and ICH incidence between open and endovascular repair are limited. In a recent meta-analysis, CEA appeared to be associated with a higher risk for CHS compared to transfemoral CAS, although this difference was seen in the older studies.[16] It has also been suggested that there is an earlier onset of CHS after CAS, possibly due to the prolonged baroreceptor stimulation by the stent that may induce bradycardia, hypotension, and ischemic damage. Many factors have been attributed with the increased risk of CHS (eg, age, diabetes, poorly controlled preprocedure hypertension, recent contralateral CEA, contralateral carotid occlusion, exhausted cerebrovascular reserve), but postoperative hypertension and inadequate control of arterial BP are probably the most important and most preventable.

CONCLUSION

Hemodynamic instability after carotid intervention necessitates an offensive strategy of early management to prevent adverse sequelae. Maintaining systolic BP between 140 and 160 mm Hg during flow reversal and between 100 and 140 mm Hg postoperatively further compounds the safety and success of TCAR. ■

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Reimbursement and Future Coverage for Transcarotid Artery Revascularization

Discussing the objectives for the TCAR Surveillance Project and how outcomes will influence CMS coverage with CMS's former Director of Coverage and Analysis Group, Dr. Louis Jacques, and study investigator, Dr. Marc L. Schermerhorn.

WITH LOUIS JACQUES, MD, AND MARC L. SCHERMERHORN, MD

What is the overall objective of the transcarotid artery revascularization (TCAR) Surveillance Project?

Dr. Schermerhorn: Our primary objective is to evaluate the 1-year stroke and perioperative stroke and death rates after TCAR and carotid endarterectomy using the Society of Vascular Surgery Vascular Quality Initiative registry.

How will data be mined from the TCAR Surveillance Project?

Dr. Schermerhorn: We're also charged with looking at periprocedural outcomes. There will be many more analyses to look at certain subgroups; the steering committee's primary focus will include symptomatic versus asymptomatic, gender, and percent stenosis. We will approve others' doing additional analyses with the data as well.

How did the TCAR Surveillance Project garner CMS coverage without a formal reconsideration of the national coverage determination (NCD)?

Dr. Jacques: The existing NCD has contained a provision that covered FDA-approved studies, and the TCAR Surveillance Project—through the work of the societies and the sponsorship of the societies—was approved by the FDA and thus was eligible for Medicare coverage.

Why would Centers for Medicare & Medicaid Services (CMS) be interested in patient outcomes with transcarotid artery stenting (TCAR)?

Dr. Jacques: CMS is fundamentally interested in the health of Medicare beneficiaries, and any technology that is designed or intended to reduce the patient's risk of stroke would be speaking to a health outcome that is of great interest to patients because of its devastating impact on patients' lives and their ability to function independently. CMS's interest reflects the significance of the condition.

How do you think TCAR is positioned in light of value- and outcomes-based payments?

Dr. Jacques: I think TCAR occupies a very interesting niche in that context. Traditionally, catheter-based technologies have involved a tradeoff between the effectiveness of a surgical procedure versus the risks or burdens of an open surgical procedure. TCAR is unique, at least based on the available evidence to date, in that it appears that patients can derive the same benefits as they would from an open surgical procedure but with less burden, fewer adverse events, and an overall simpler treatment paradigm.

How does TCAR compare to carotid endarterectomy (CEA) in terms of unadjusted and risk-adjusted evaluations?

Dr. Schermerhorn: Unadjusted analyses are always an appropriate place to start, but it's not really a fair comparison because the patients undergoing TCAR are different than those undergoing CEA. We're comparing people who are older and sicker, have a lot more cardiac disease, and were more likely to be symptomatic compared to patients undergoing CEA. In the unadjusted analysis, there was no difference in our primary outcomes of in-hospital stroke and death. As a secondary analysis, we looked at stroke, death, and myocardial infarction separately. We are able to review 30-day mortality using the Social Security Death Index.

For all those outcomes, there were no differences on the unadjusted analysis, which I think speaks strongly in favor of TCAR. For certain other outcomes such as cranial nerve injury, prolonged length of stay, and operating room time, TCAR actually did better. The adjusted analysis results were still the same for stroke, death, and myocardial infarction

outcomes between TCAR and CEA, either as individual or combined endpoints.

What happens if the current NCD is reconsidered during or after CREST 2?

Dr. Jacques: I think it's reasonable to expect that the NCD would be reconsidered at some point in the future, more likely after the completion of CREST 2. At that point, based on Medicare precedents, CMS would look at the available evidence for the various carotid revascularization technologies that are subject to the current NCD and attempt to make a definitive coverage decision that does not require ongoing data collection. If that were to take place (several years from now, at the earliest), I would think that the TCAR Surveillance Project would have accumulated enough data to inform definitive decisions about the coverability of TCAR. If the current trends from the ROADSTER studies and ongoing study remain, then I would anticipate that TCAR would simply be covered outright without the need to include it in any sort of study protocol.

What are the long-term goals of the TCAR Surveillance Project? The number of patients being evaluated was recently updated to 15,000 on clinicaltrials.gov—is it the intention of the TCAR Surveillance Project to amass tens of thousands of patients like they have for CEA?

Dr. Schermerhorn: Absolutely.

As far as long-term goals, many questions remain. Other analyses suggest that stenting is more dangerous for people who have had a stroke as their symptom, particularly if the intervention was performed soon after a stroke. It is not clear whether TCAR provides protection in that subgroup of patients, so I think that will be interesting to study.

Looking at the effect of age will also be important. We know that with transfemoral stenting, older age is a marker for poor outcomes. It is not clear if that is because older patients have more debris in their arches (in which case TCAR should be protective), or if a typical distal filter causes problems (again making flow reversal a potentially better option for those patients).

We know in some analyses for CEA that women do not fare as well as men and stand to benefit less. A gender comparison will be interesting. Once we have a larger number of patients, we can determine if those variables have an impact.

Additionally, as we have more surgeons involved in the procedure, we can observe experience. These early results with TCAR are excellent and comparable to CEA, and it will be interesting to see if they can improve further, and if experience brings further improvement. In this study, many of the operators were fairly new to the procedure. ■

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