First Fully Autonomous Transcranial Doppler Robotic system during Carotid Artery Stenting

Kavya Sinha MD, Pooja Tekula MD, Busra Tok Cekmecelioglu MD, Zsolt Garami MD, Alan B Lumsden MD
Houston Methodist DeBakey Heart & Vascular Center

Background/Introduction

Transcranial Doppler (TCD) is a non-invasive, safe and cost effective bedside test that can be used to evaluate cerebral circulation, particularly the middle cerebral arteries. TCD remains the only method to detect asymptomatic embolization by providing real-time hemodynamic information about the intracranial circulation compared to static brain imaging modalities.

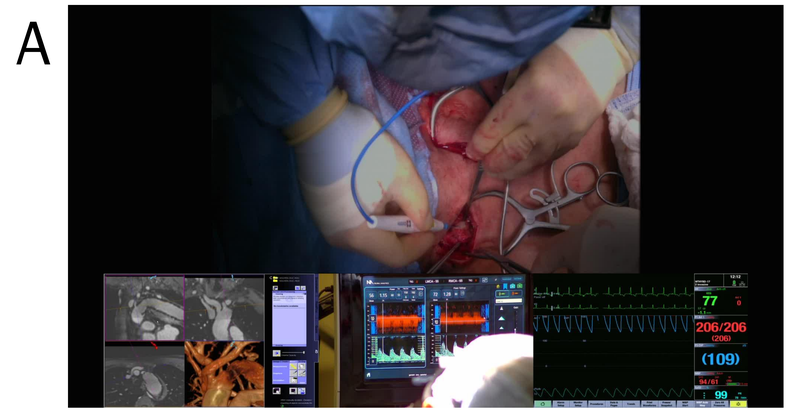
Purpose/Objectives/Hypothesis

Neurological complications related to carotid interventions are usually due to perioperative hypoperfusion, hyperperfusion, or most commonly, thrombosis and embolism. In addition to symptomatic thromboembolic events, silent subclinical cerebro-embolism occurs at an even higher rate. Monitoring for and real-time detection of such events with TCD are critical to prevent, diagnose, and reverse procedural complications. TCD monitoring of the middle cerebral artery is a valuable tool that quickly alerts clinicians to these complications.

Methods

A 70-year-old male who previously underwent a Thoracic Endovascular Aortic Repair (TEVAR) and a Carotid artery bypass, returned for a left common carotid artery stent (CAS)placement.
This was the first case in a clinical commercial setting in which a fully autonomous TCD robotic system was implemented.
The NovaGuide (Novasignal, Los Angeles, CA) was setup on the patient within two minutes of general anesthesia induction.
(Fig, B) The probes have five degrees of freedom, mimicking the sonographer in probe placement and signal acquisition in a fully automated manner.

Result



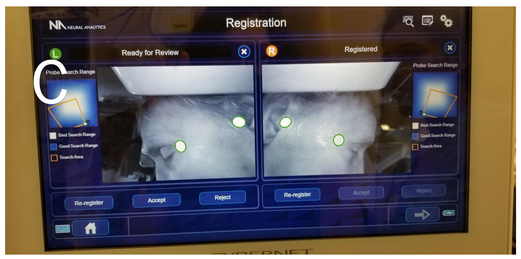


Fig A: Real-time TCD monitoring in quad format
Fig B: Depicts pod placement
Fig C: Registration of fiducials and temporal window
Fig D: Shows the pod

Results/Implications

Bilateral MCA signals were secured by the LRS. We were able to localize the right middle cerebral artery signal in 22 seconds and the left MCA in 44 seconds. Velocity changes were noticed mainly during the stent placement with the majority of embolic signals detected during the contrast injections and catheter movement. The procedure ended with improved waveforms and a total of 114/97 (right/left) emboli signals (HITS) were identified.
With the use of a fully autonomous TCD robotic system provided the ability to insonate and monitor bilateral MCA's throughout the procedure, whilst streaming continuous data in real-time and providing critical information on changes in cerebral blood flow velocity (CBFV) and counting embolic particulate entering the cerebral vasculature. With this monitoring approach, we could minimize the procedural and anesthesia workflow interruption.

Future Actions

TCD, though non-invasive and very useful during procedures, Is under utilized due to the lack of expertise and experience in operating room monitoring. By replacing the expert sonologist with automated robotic probe placement and signal finding process, we could minimize interruptions due to probe shifting and signal loss.

References

Jeong HS, Song HJ, Lee JH, Choi SW, Kim J. Interpretation of TCD spectral patterns detected during carotid artery stent interventions. J Endovasc Ther. 2011 Aug;18(4):518-26. doi: 10.1583/11-3400.1. PMID: 21861741.

Spacek M, Sorrell VL, Veselka J. Transcranial Doppler Ultrasound in the Current Era of Carotid Artery Stenting. Ultraschall Med. 2015 Aug;36(4):337-41. doi: 10.1055/s-0034-1366677. Epub 2014 Jun 25. PMID: 24963921.

Stabile E, Sannino A, Schiattarella GG, Gargiulo G, Toscano E, Brevetti L, Scudiero F, Giugliano G, Perrino C, Trimarco B, Esposito G. Cerebral embolic lesions detected with diffusion-weighted magnetic resonance imaging following carotid artery stenting: a meta-analysis of 8 studies comparing filter cerebral protection and proximal balloon occlusion. JACC Cardiovasc Interv. 2014 Oct;7(10):1177-83. doi: 10.1016/j.jcin.2014.05.019. Epub 2014 Sep 17. PMID: 25240544.

Yan Z, Yang M, Niu G, Zhang B, Tong X, Guo H, Zou Y. Hemodynamic Surveillance of Unilateral Carotid Artery Stenting in Patients With or Without Contralateral Carotid Occlusion by TCD/TCCD in the Early Stage Following Procedure. Front Neurol. 2019 Sep 4;10:958. doi: 10.3389/fneur.2019.00958. PMID: 31551915; PMCID: PMC6737047.

Mergeche JL, Bruce SS, Sander Connolly E, Heyer EJ. Reduced middle cerebral artery velocity during cross-clamp predicts cognitive dysfunction after carotid endarterectomy. J Clin Neurosci. 2014 Mar;21(3):406-11. doi: 10.1016/j.jocn.2013.05.010. Epub 2013 Sep 3. PMID: 24008048; PMCID: PMC3946387.