Teleneurosonology: A Novel Application of Transcranial and Carotid Ultrasound

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Background: To demonstrate the technical feasibility of interfacing transcranial Doppler (TCD) and carotid "duplex" ultrasonography (CUS) peripherals with telemedicine end points to provide real-time spectral waveform and duplex imaging data for remote review and interpretation. *Methods:* We performed remote TCD and CUS examinations on a healthy, volunteer employee from our institution without known cerebrovascular disease. The telemedicine end point was stationed in our institution's hospital where the neurosonology examinations took place and the control station was in a dedicated telemedicine room in a separate building. The examinations were performed by a postgraduate level neurohospitalist trainee (M.N.R.) and interpreted by an attending vascular neurologist, both with experience in the performance and interpretation of TCD and CUS. *Results:* Spectral waveform and duplex ultrasound data were successfully transmitted from TCD and CUS instruments through a telemedicine end point to a remote reviewer at a control station. Image quality was preserved in all cases, and technical failures were not encountered. *Conclusions:* This proof-of-concept study demonstrates the technical feasibility of interfacing TCD and CUS peripherals with a telemedicine end point to provide real-time spectral waveform and duplex imaging data for remote review and interpretation. Medical diagnostic and telemedicine devices should be equipped with interfaces that allow simple transmission of high-quality audio and video information from the medical devices to the telemedicine technology. Further study is encouraged to determine the clinical impact of teleneurosonology. **Key Words:** Telestroke—acute stroke—transcranial Doppler—carotid ultrasound—sonology—telemedicine.

The use of telestroke infrastructure for a basic acute stroke evaluation and thrombolysis decision making is mainstream and supported by a robust literature base.[1] There is very little literature on the use of telestroke for other phases of stroke care,[2] including facilitation of advanced diagnostics in the acute setting that can influence clinical decision making. The advanced diagnostics most typically employed in the hyperacute stroke setting are computed tomographic and magnetic resonance imaging–based angiography and perfusion studies. Although these studies can provide rich detail of vascular anatomy and a surrogate of the pathophysiologic process,

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availability and expertise are not universal, and both studies are costly, bringing into question the feasibility of their expansive use. Neurosonology, including transcranial Doppler (TCD) and carotid "duplex" ultrasonography (CUS, B-mode/color flow Doppler), is an inexpensive, safe, noninvasive, validated and expeditious[3-7] means of screening for major steno-occlusive disease in the basal intracranial and cervical arterial vasculature in acute stroke. Telestroke infrastructure interfaced with neurosonology instruments such as TCD or CUS facilitates ultrasound data acquisition in real time from a remote site and serves as another means of extending cerebrovascular expertise. Advanced diagnostic capability, including neurosonology, is a tenet of comprehensive stroke center certification.[8] The objective of this endeavor was to demonstrate the feasibility of interfacing TCD and CUS instruments with telemedicine devices to provide real-time spectral waveform and duplex data to a desktop control station for review. Herein, we describe our remote, real-time TCD and CUS methodology, termed "teleneurosonology."

Methods

We performed remote TCD and CUS examinations on a healthy, volunteer employee from our institution without known cerebrovascular disease. The telemedicine end point was stationed in our institution's hospital where the neurosonology examinations took place and the control station was in a dedicated telemedicine room in a separate building. The examinations were performed by a postgraduate level neurohospitalist trainee (M.N.R.) and interpreted by an attending vascular neurologist, both with experience in the performance and interpretation of TCD and CUS.

Telemedicine Device

The telemedicine devices used was the RP Lite endpoint and a Windows-based control station (InTouch Health, Santa Barbara, CA). The end point had a "female" coaxial (Bayonet Neill–Concelman [BNC]) and Separate Video (S-Video) input interface for auxiliary video data. The desktop control station software allowed for simultaneous viewing of the primary feed from the end point camera and the auxiliary video feed of the spectral waveform and duplex imaging data (Fig 1). Audio was not transmitted directly between the neurosonology peripherals and the telemedicine end point, but the microphone of the telemedicine end point was able to capture audio data projected from the internal speakers of the neurosonology peripherals. The telemedicine end point and control station were connected to our institution's Health Insurance Portability and Accountability Act–compliant, secure wireless network for internet connectivity.

Figure 1. *A remote stroke specialist is able to review neurosonology data in real time in parallel with clinical data from the standard 2-way audio–visual interaction.*

Neurosonology Peripherals

All neurosonology instruments used have United States Food and Drug Administration approval for the performance of a diagnostic examination. The TCD device used was a Spencer ST3 (Spencer Technologies, Seattle, WA). A standard handheld 2 MHz probe was used to acquire Doppler waveform of a proximal segment of the volunteer's left middle cerebral artery through the transtemporal window (55-65 mm of depth). Video data came from the video graphics array (VGA) signal output of the TCD device. The CUS device was a SonoSite M-Turbo (SonoSite Inc, Bothell, WA). A linear probe (HFL38× Transducer, 6-13 MHz) was used to acquire B-mode and color flow imaging of the left carotid artery. Video data came from the S-Video signal output of the device.

Interfacing Components

The telemedicine end point and TCD peripheral were interfaced with a VGA-to-Radio Corporation of America (RCA) converter and an RCA-to-BNC cable, both ends "male." The adjustment keys on the VGA-to-RCA converter allowed for custom alignment and resolution of the video data for presentation to the remote reviewer. The CUS peripheral was connected directly to the telemedicine end point with an S-Video cable, both ends "male" (Fig 2).

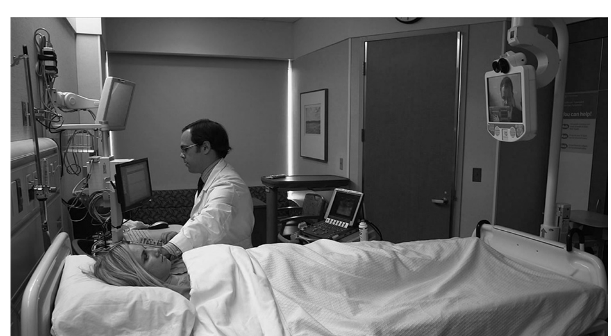

Figure 2. *Neurosonology devices as telemedicine peripherals: "teleneurosonology."*