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Assembly of a Multi-channel Video System to Simultaneously Record Cerebral Emboli with Cerebral Imaging

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Abstract

Stroke remains a significant risk of carotid revascularization for atherosclerotic disease. Emboli generated at the time of treatment either using endarterectomy or stent-angioplasty may progress with blood flow and lodge in brain arteries. Recently, the use of protection devices to trap emboli created at the time of revascularization has helped to establish a role for stent-supported angioplasty compared with endarterectomy. Several devices have been developed to reduce or detect emboli that may be dislodged during carotid artery stenting (CAS) to treat carotid artery stenosis. A significant challenge in assessing the efficacy of these devices is precisely determining when emboli are dislodged in real-time. To address this challenge, we devised a method of simultaneously recording fluoroscopic images, transcranial Doppler (TCD) data, vital signs, and digital video of the patient/physician. This method permits accurate causative analysis and allows procedural events to be precisely correlated to embolic events in real-time.

Introduction

The prevention of stroke in patients with high-grade carotid artery stenosis has been traditionally carried out by carotid endarterectomy (CEA). An increasing percentage of patients are now being treated with carotid artery stenting due to its less invasive nature 1. The incidence of new neurologic deficits associated with CAS was initially very high 2. Most of these deficits are attributable to emboli, which can be monitored and documented by TCD ultrasonography^{3–7}. Many of these emboli are presumed to produce cerebral ischemia, which may be recognized after the procedure by diffusion-weighted MRI imaging 2, 6, 8–13. It has been recognized that cerebral emboli can result in subtle cognitive dysfunction that may be overlooked by commonly-performed outcome measures. Several devices have been developed to reduce or detect emboli that may be dislodged^{14, 15, 9, 16, 17}.

One of the main challenges in assessing the efficacy of these devices is precisely determining when emboli are dislodged in a real-time setting. To address this challenge, we have assembled a multi-channel videographic system to simultaneously record fluoroscopic images, TCD data, vital signs, and digital video of the patient/physician. This multi-channel videographic system allows us to precisely correlate events occurring during the endovascular procedure with events detected by our TCD monitor. In this paper we present the details of assembling a multi-channel videographic system with the intention that others may adapt it for their own purposes.

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Disclosures: None

Methods

Instruments

Figure 1 represents an outline of the four channels that we display and record on our four channel digital video recorder (DVR). We describe in detail how these channels are connected to the DVR in the following sections.

Transcranial Doppler

Our machine is an ST3 transcranial Doppler machine (Spencer Technologies, Seattle, WA) with a 2MHz probe. The probe is applied over the temporal region of the head to insonate on the middle cerebral artery at an approximate depth of 50 mm from the scalp. The TCD machine has a vertically divided display; the upper section shows a Power M-mode (Figure 2, B(i)), which is similar to an ultra-sound mode, and the bottom section shows a spectrogram where the velocity profile is derived from the distance from the scalp as indicated by the yellow horizontal bar on the upper display (Figure 2, B(ii)). The TCD machine provides a 15-pin Video Graphics Array (VGA) output at a resolution of 800×600 which is used to record the screen image. The resolution 800×600 is the numbers of columns by the numbers of rows. It is a function of the size of the display. The number of pixels is the product of the number of columns and rows, for example 800×600 has 480K pixels/display. The VGA output is converted to a composite video signal on a simple RCA jack using a PC to Video EZ converter GEZ-100 (Grandtec, Dallas, TX) (Figure 1, II). Our digital video recorder (DVR, model CS-4404, SCW LLC., Waynesville, NC) has BNC inputs, thus the composite signal is passed through an RCA to BNC adapter to the DVR.

X-Ray Machine and Fluoroscopy

We are able to capture fluoroscopic images from two different models of Siemens angiography machines. The fluoroscopic video output is a high-definition (HD) signal. The resolution must be reduced for all commercially available multi-channel recording devices. The reduction in resolution is done in one of two ways. For Siemens AXIOM-Artis (Siemens, Erlangen, Germany) control room configurations, which use an HD composite signal (1024 line NTSC video) for the live feed output, the signal is degraded through a Perkins down-scan converter (PKP-02720-000, Perkins Electronics, Dallas, TX) before connecting to the DVR unit (Figure 1). For Siemens Artis Zeego (Siemens AG, Erlangen, Germany) control room configurations, which use a digital visual interface (DVI) for the live feed output, the signal is first adapted to a high-definition multimedia interface (HDMI) plug with a simple adapter, and then scaled down via a GefenTV HDMI to Composite Scaler (GTV-HDMI-2-COMPSVIDS, Gefen LLC, Chatsworth, CA) (Figure 1, I). Both of these methods yield a signal that can be recorded on the DVR device and is displayed as input into channel 1 (Figure 1, I and Figure 2, A).

We recognize that other investigators may have different devices and may require slightly different assembly practices, but this method still provides a general configuration guide of the multi-channel videographic system. All video outputs are routed to a 1U Series 4-channel SCW DVR device as composite video signals ending in BNC jacks. Video is visualized on a Dell E171FPb monitor connected to the DVR via a VGA cable.

Vital Signs

All vital signs from the anesthesia monitoring machine (Datex Ohmeda Aisys Carestation, Madison, WI) and patient monitoring machine (Philips IntelliVue MP90, Eindhoven, Netherlands) are recorded via a VGA output. Anesthesia machines are frequently and uniquely configured for the needs of an institution, so it is likely that there will be variability between respective vital sign recordings. The VGA signal obtained from the Intellivue is

converted via a GEZ-100 PC to Video EZ converter to composite video which is recorded onto the DVR (*VGA input sent from the anesthesia monitor via VGA cable is sent out to the DVR via a standard video cable*) (Figure 1, III). The video graphics received from the converter is displayed with up to 1280 X 1024 resolution (Figure 2, C).

Digital Video Camera

We have a digital video recording camera (Everfocus Digital Color Video Camera EQ500A/NN, Everfocus Electronics Corporation, Hauppauge, NY) with a composite signal output (Figure 2, D). The camera is mounted to a cart using a Manfrotto flexible arm/clamp assembly with a small Slik ball head attached to allow for camera alignment. The camera is powered by a 12V battery, but can also be connected directly to a standard 110V outlet. The camera is equipped with a zoom lens (Fujinon YV5x2.7R4B-SA2L, 1:1.3/2.7–13.5mm, 1/3" CS Zoom Lens, Fujifilm Optical Devices U.S.A., Inc., Wayne, NJ). No signal conversion is necessary.

Multi-Window Digital Video Recording

We use a DVR screen divided into four quadrants or channels. Each of the four devices occupies one of these quadrants (Figure 2). Channel 1 displays the fluoroscopic image, channel 2 the TCD display, channel 3 the vital signs from the anesthesia monitor, and channel 4 the digital video camera.

Results

The DVR screen is shown below with the four quadrants displaying the output of each of the four devices as described above (Figure 2, A–D).

Discussion

All of the cases recorded were part of an IRB approved study. The procedures required fluoroscopic imaging, which was performed by the endovascular physician, and would have been performed and recorded whether or not we were studying the patient. The results were not used for clinical management. The primary advantage of this multi-channel videographic recording system is that we can continuously and simultaneously record and display four sources of information and that the images remain synchronized in time. While it is not ideal to reduce the high output resolution from the X-ray units, the signal still provides enough resolution for visualization of endovascular devices. This problem can be addressed in the future with affordable multi-channel recorders that can capture HD signals like those outputs by the X-ray machines. Additionally, TCD data is recorded redundantly on the TCD device, which can be referenced if DVR resolution is not sufficient. While the individuals working for Siemens readily provided us with the technical specifications required to convert their fluoroscopic images to images that could be recorded on our DVR machine, not all X-ray companies are as accommodating.

The ease and accuracy of review of this video data provides a cost-effective platform for clinical researchers to analyze complex procedures by aggregating real-time data from multiple pieces of equipment. Such methods have often been used in the laboratory setting but to our knowledge, they have not been available in the clinical setting. This system eliminates timestamp inaccuracies and gives second-by-second correlations between fluoroscopic video footage and an adaptable array of monitors and cameras.

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Figure 1.

Diagram with four inputs: (I) Siemens Artis Zeego angiographic machine, (II) Transcranial Doppler (TCD), (III) Vital signs, and (IV) Camera. The converters are described in the methods section.

Figure 2. Multichannel DVR screen with four channels VGA screen

(A) Fluoroscopy Image (B) Transcranial Doppler *i.* Power M-mode showing MCA blood flow selected at a depth of 50mm. A yellow bar in the screen indicates the selected depth. *ii.* Spectrogram displays the velocity waveform at a corresponding depth. (C) Vital Signs (D) Video Camera Image. The digital video camera is directed towards the endovascular physician and operative site so as to follow intra-operative events. In order to maintain confidentiality the patient's face is obscured by the X-ray tube.