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The Heart Surgery Forum®

EDITORIAL

Intraoperative Monitoring During Cardiac Surgery: Some Observations

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For years, the combination of a radial artery line, central venous access, and Swan-Ganz hemodynamic monitoring have been the standard for most openheart surgical cases. In healthier patients with normal left ventricular (LV) function, pulmonary artery (PA) catheters are probably not necessary and many centers have dropped their routine usage due to cost and the occasional PA rupture associated with their use. As cardiac surgery continues to progress forward (with off-pump and minimally invasive procedures), it is time to rethink what intraoperative monitoring is needed.

One advance that has been available for some time now is the addition of continuous venous saturation (SvO2) available from modern PA catheters. Continuous SvO2 does provide some assurances that tissue ischemia is not occurring during the post-pump period, but there are many influences that affect the final saturation value, such as hematocrit, cardiac output, and arterial saturation. In my experience, the value of SvO2 lies in the first few hours of intensive care monitoring following surgery. In this setting, venous saturation values tend to change early with tamponade or low cardiac output and thus assist in the decision to treat either of these entities. However, the value of SvO2 as a solo number without the other hemodynamic information is limited and may not justify the additional expense of the specialized catheter and monitoring equipment.

Another advance is the ability of newer pulmonary artery catheters to provide continuous cardiac output. This is more valuable to me than continuous SvO2, but they do compliment each other. Within the first few minutes of weaning from the pump, continuous C.O. values are often artificially elevated, probably due to slow rewarming of the catheter tip. However, within 10 minutes or so, reliable numbers are obtained. It appears that continuous C.O. provides additional diagnostic value during those inevitable ups and downs in blood pressure that occur as protamine is administered and volume shifts influence the end of the case. In the intensive care unit, the decision to begin inotrope or volume therapy is a bit more refined when one knows the cardiac index before and after treatment. It is true that manual thermodilution cardiac outputs are essentially the same, but in a busy unit, the automatic generation of this important number on a frequent basis, associated with trend plotting, is very helpful.

It is an individual decision of each surgeon or program whether the cost/benefit of continuous C.O. and SvO2 are worthwhile. When performing OPCAB, the additional information obtained while positioning and stabilizing the heart is reassuring and helpful. In MIDCAB or other minimally invasive procedures where the heart cannot be seen by the surgeon or anesthesiologist, these catheters are very useful to give a direct indication of the condition of the heart during vessel clamping.

I thought I would pass along a few lessons about intraoperative monitoring that are nearly cost free. The first is about measuring arterial pressure. The current standard method is a radial artery catheter. However, the radial artery is small (about 2 mm) and is a muscular vessel prone to spasm. During CPB (particularly with hypothermia), the radial artery catheter may gradually dampen and the recorded value fall. This leads the anesthesiologist or perfusionist to treat the appearance of hypotension with vasopressors such as phenlyephrine. This alpha agent is a potent vasoconstrictor that may simply aggrevate the radial artery spasm and lower the recorded pressure again. This leads to more alpha vasoconstrictor. This cycle can lead to high dose pressor usage, which causes tissue hypoperfusion and acidosis during CPB. In this situation, the problem is not with the patient, but with the technique of monitoring.

The answer is a more reliable source of central pressure monitoring. My friend Charles Scoliaro, MD in Kansas City places a femoral catheter in every patient after the induction of anesthesia. I also saw the same technique when visiting the OPCAB program of John Pym, MD in Kingston, Ontario. Dr. Pym's assistant routinely places a 4¼ inch 18 gauge Arrow catheter into the femoral artery in every case. This catheter kit [FA-04018, Arrow International, Reading, PA] includes a guidewire to facilitate insertion.

The femoral artery is a better site for monitoring because it is larger and less prone to spasm. However, not everyone has a normal aortoiliac or femoral system. Before relying on the femoral artery, the surgeon must know the status of the patients' pulses and potential symptoms of claudication. There are patients with extensive gluteal col-

laterals that have a palpable femoral pulse but a totally occluded iliac system. A good vascular history will detect this patient. Otherwise, liberal use of femoral artery monitoring lines is recommended to eliminate the effect of radial spasm, catheter kinking, or inadvertent movement of the patient's arm or wrist under the drapes which can reduce the measured pressure leading to an inappropriate treatment. An additional benefit of early femoral artery access is the speed at which an intra-aortic balloon pump (IABP) can be placed when needed using guidewire and exchange techniques.

For years, I have taken part of this recommendation as my daily practice. I don't always use a femoral line, but I do always use a root pressure catheter when weaning from the pump. In every case, I attach a pressure line to my cardioplegia cannula before beginning to wean from the bypass circuit. Usually, I just swing the retrograde pressure monitoring line over to the anterograde cardioplegia cannula. What I have observed is quite interesting. When I cool below 30 degrees, the root and radial pressures are often different. If I were to react and start pressors based on the radial artery value, it would not be physiologically correct or necessary. As pulsatile pressure returns and the patient rewarms, the difference between the radial and root pressure often disappears. If not, the patient must be weaned with a central pressure monitor of some sort, such as a femoral line.

Placing a femoral line at the end of the pump run is a more different challenge than placing it at the beginning of the case. At the end of the pump run, time is of the essence. Also, while still on cardiopulmonary bypass, the femoral artery has no pulse. This makes it hard to locate the femoral artery when you need it the most. The same analogy applies when a balloon pump is clearly needed for LV failure.

Now for the answer ... the Site-Rite two-dimensional echo probe (see Figure 1). This device may be one of the most important surgical tools of the recent decade. It provides a simple and easy way to monitor many different aspects of the procedure. Leon Skolnick, MD, a radiologist in Pittsburgh Pennsylvania, with ultrasound experience invented the device. The original intent was to build a tool to facilitate central line insertions. The Site-Rite does this in a grand way and will also locate the femoral artery for you in seconds.

The device has only 3 knobs (depth marker, power, and gain). No technical training is needed. It can be used successfully on the first try. The femoral artery can be distinguished from the femoral vein (in a transverse scan) by the collapsing property of the vein when balloted with the scanning probe. Using this information and knowledge of the anatomy (vein medial, artery lateral), the pulseless femoral artery on CPB can be located without a cutdown or any delay in the case.

The Site-Rite offers two probes, a 7.5 MHz and a 9 MHz. The probe tip comes with a built-in mechanical standoff, which moves the ultrasonic transducer away from the surface allowing for sharp focus and detail of structures very close to the device tip. The 9 MHz probe provides greater resolution and is the one I am using for all my scans. The unit comes with disposable sterile sheaths and gel (for $8 each). The inventor also developed a snap-on clip that attaches to the center of the probe and acts as a guide for the exploring needle. I have found that this guide is rarely needed. Once the vessel is imaged, you can watch the passage of the needle on the screen using a few tricks. First of all, the needle causes acoustic shadowing that is manifest as a vertical line on the screen that moves when you move the needle. Second, if you poke the needle sharply with a forward motion, the tissue in front of the needle shakes a little. Using theses visual clues, you can pinpoint the location of the needle tip in relation to the femoral artery (or other vessel). Amazingly, as you poke the needle farther towards the target, arterial blood comes out. I have now placed about 10 emergency femoral lines with the Site-Rite during CPB and have never missed one yet. This takes only minutes and removes cutdown as an option.

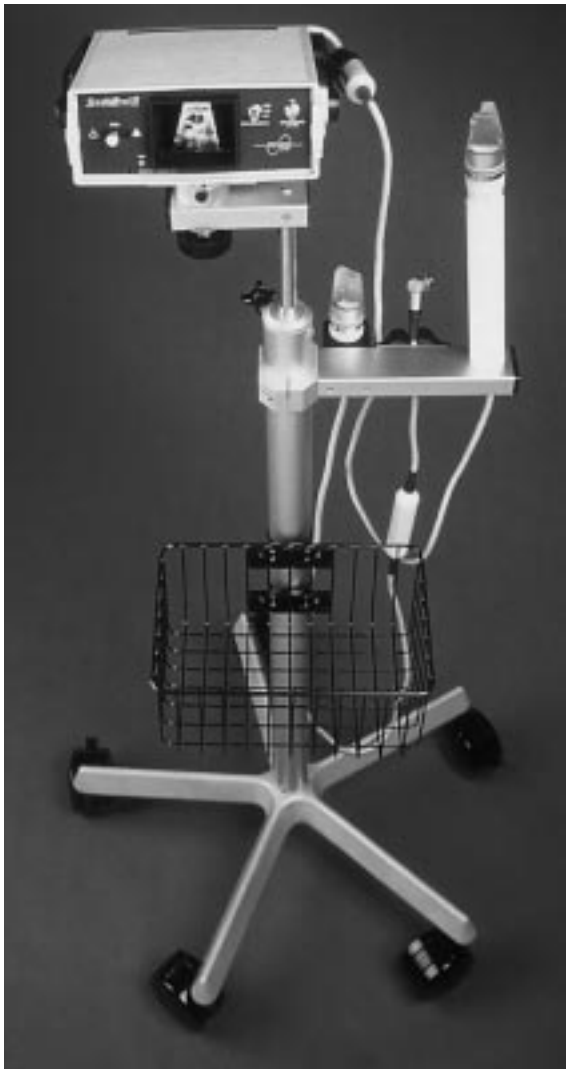

Figure 1: The Site-Rite II device for vessel location and epiaortic ultrasound.

The Site-Rite can find many other things too. It is a fantastic epiaortic ultrasound probe. There are now many papers on the value of epiaortic ultrasound in preventing perioperative stroke in cardiac surgery [Marshall 1989, Ribakove 1992, Wareing 1992]. An excellent review of the importance of ascending aortic atherosclerosis and the role of epiaortic scanning by Johannes Bonatti is presented on page 125 of this issue. Not everyone can afford the expense of a new echo machine for every operating room. The Site-Rite device costs $11,000 and is totally portable (including batteries). It gives excellent images of the ascending aorta and proximal arch (an area that transesophageal echo tends to image poorly). The probe has a built in standoff, which allows the user to scan the aorta, without holding the probe up by the sternal retractor and without saline in the chest. I just place the sleeved probe right onto the aorta without any topical gel or fluid.

In my first two uses of the Site-Rite as an epiaortic probe, I found grade 3 posterior wall plaques in the ascending aorta that were exactly at the anticipated site of the cross clamp. By knowing this and adjusting the technique, I avoided disturbing these plaques. Both patients were neurologically intact. In my last 8 months of using the Site-Rite for epiaortic scanning in every case, the frequency of surgical technique modification due to aortic plaque discovered by epiaortic ultrasound is averaging around 20%.

I could not resist trying the Site-Rite for other tough problems in cardiac surgery. My next venture was to look for intramyocardial coronary arteries with this device. No problem. In several cases where there was no visible LAD seen after opening the pericardium, I put the Site-Rite on the interventricular septum (at the 2-cm depth setting). In every case, I found the LAD immediately, and could measure the course and depth of the vessel perfectly. All patients underwent successful intramyocardial LAD grafting without the need to search empirically in the muscle.

Next, I pointed the probe to the aortic valve. You can see every leaflet in full motion. This means that the surgeon can now examine the aortic valve in those cases of "sclerosis without stenosis" where the cardiologist is not sure how tight the valve is. The Site-Rite also allows you to visualize your completed aortic valve prosthesis in real time. The mitral valve cannot be reached with the currently marketed probe, but the tricuspid is easily seen, as is the atrial septum.

Another gain of this device is the ability to perform saphenous vein mapping. The device quickly locates and maps the saphenous vein, allowing the surgeon to find vein in any tough leg, to decide which vein segment is too small or too enlarged (varicose), and to eliminate the leg with the dual system or absent vein. This can be a real time saver as it prevents exploring a leg where the vein is not adequate for grafting. In the era of minimally invasive and endoscopic vein harvesting, the operator can locate the saphenous at the knee in less than 5 seconds and know exactly where to cut and how deep the main vein lies. For the open technique, knowing the exact course of the vein reduces the tendency to create flaps and improves wound healing.

Once this probe is in your own hands, you will quickly find other uses. I perform pacemaker implants, and have used the Site-Rite many times to locate the subclavian vein. My first discovery was that there is a lot more variability in the subclavian vein anatomy than I expected. The vein can be more medial, more lateral and in some cases more superficial than expected. I found the same variability when viewing the internal jugular vein in the neck. The incidence of complications during subclavian line insertion may well be next to zero when using the Site-Rite. The danger of missing the vessel and accidentally puncturing the lung or subclavian artery can be eliminated from the procedure. Subclavian lines tend to be more comfortable for the patient than internal jugular lines. I feel it is an advantage to migrate back to subclavian lines if inadvertent injury to the lung and/or artery can be avoided. This is one of the additional benefits of the Site-Rite device.

Epicardial ultrasound can also be used to evaluate the apex for mural thrombus. If found, the thrombus should be removed after cross clamping to prevent dislodgment and intraoperative stroke [Hartman 1983, Nili 1988, Levinson 1995]. In the situation where intra-operative aortic dissection is suspected (abnormal aortic bleeding or expanding hematomas), the Site-Rite can immediately rule out or detect a dissection flap and permit rapid decision-making.

The screen display on the Site-Rite gives very clear pictures, but I cannot show examples here because the refresh speed is too slow and pictures taken with still or video cameras contain a lot of artifact. You can see some images and get more information on the device by visiting the Dymax Corp. World Wide Web site at http://www.site-rite.com.

Transesophageal echo (TEE) is a monitoring tool equal in power and versatility, but more expensive and more cumbersome to use. Its role in evaluating the results of valve reconstruction is unequalled. There is now excellent data to show that port access surgery (such as HeartPort®) can be safely monitored (including the position of all cannulas and devices) with just TEE visualization [Schultze 1999]. This is a very important discovery since one of the leading complications has been migration of the endo-aortic balloon cross-clamp across the aortic valve or into the region of the innominate. TEE can also detect early wall motion abnormalities during target vessel occlusion in MIDCAB or OPCAB that may indicate the need for an intracoronary shunt device [Rivetti 1998]

Monitoring of cerebral function and embolism detection are newer frontiers of intraoperative monitoring. Transcranial doppler (TCD) permits the surgeon to visualize intracerebral flow velocity during manipulation of the heart (OPCAB) or during cardiopulmonary bypass. TCD is also exquisitely sensitive to small particulate emboli, either gas or solid. Commercial TCD units are now available (MedaSonics Inc). My experience with TCD indicates that

several parts of a standard cardiac procedure do elicit emboli, such as the insertion of a ventricular vent prior to cross clamping. TCD can provide meaningful information that educates the surgeon as to the neurologic risk of each move of the case. This same educational process was seen when TCD was first used in carotid surgery, with a corresponding decrease in stroke complications as subsequent refinements were made in surgical technique [Spencer 1997].

There are now additional cerebral monitoring devices available. One device provides mixed (arterial and venous) cerebral cortical saturation through the intact cranium. Early experience with this device indicates that positioning of the heart and hypotension is not typically associated with cerebral hypoxia. In the next few months, watch The Heart Surgery Forum® for a presentation by Novitsky on hypotensive anesthesia during OPCAB which outlines the use of multiple cerebral monitors including TCD, cerebral oximetry, and electroencephalography (EEG) to permit control of anesthetic depth and cerebral perfusion while positioning the heart.

For those who believe that intraoperative monitoring of the cardiac surgery patient has changed little in the recent years, look again. The advantages of using these new tools will permit safer surgery in the ever increasingly difficult cases being referred for surgery and particularly in view of the newer and more challenging surgical techniques coming into practice.

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Disclaimer:
The author has no financial or other interest in Dymax Corp. supplier of the Site-Rite device. Full information on the device can be obtained from the manufacturer's Web site at http://www.site-rite.com/

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