The ins and outs of hemodynamic monitoring

EVEN IF YOU AREN’T a critical care nurse, you should understand the vascular access devices used in the invasive hemodynamic monitoring of critically ill or unstable patients. Let’s learn what they’re all about.

What’s hemodynamic monitoring?

The term hemodynamic relates to blood circulation. What that means is that hemodynamic measurements describe the intravascular pressure and flow occurring when the heart muscle contracts and pumps blood throughout the body via the vascular system.

The heart (a pump), blood (volume for the pump to move), and vascular tone (resistance against the pump) are the three elements that combine to keep the vascular system in working order. Hemodynamic measurements relate the status of these elements.

Both invasive and noninvasive techniques can be used to determine a patient’s hemodynamic status. Every time you take a patient’s blood pressure, you’re using a noninvasive hemodynamic monitoring device. It helps you determine three hemodynamic parameters: the systolic, diastolic, and mean pressures (using the systolic and diastolic pressures to calculate the mean pressure).

The primary purpose of invasive hemodynamic monitoring is to detect and monitor changes in intravascular pressures and cardiac output, which allows for optimum patient management. With invasive hemodynamic monitoring, specialized catheters, intravenous (I.V.) tubing, and instruments are inserted into the vascular system to measure pressures.

Making waves

Most invasive hemodynamic monitoring systems work pretty similarly, and they usually have three components: a transducer, an amplifier, and a recorder/monitor. The transducer converts the fluid waves generated by blood flow into electrical signals that are presented numerically by electronic monitoring equipment. The amplifier, which increases the size of the signal from the transducer, is located inside the bedside monitor. A recorder or monitor displays the signal and records information.

Other hemodynamic monitoring equipment is needed as well. For example, only semi-rigid pressure tubing can be used; changes in pressure from tubing distention would cause inaccurate readings. This tubing has an intraflow flush device to maintain patency of the catheter tip, as well as a manual flush device to flush out air bubbles and to rapidly flush the line after blood sampling.

The tubing is connected to an infusion bag, which usually contains a heparin solution of 1,000 units in 500 ml of 0.9% sodium chloride. The bag is placed inside an inflated pressure bag to maintain a constant pressure—usually 300 mm Hg—within the line. This prevents arterial blood from backing up into the pressure tubing. The transducer is
kept at the level of the right atrium, usually on an I.V. pole.

The offensive line
Let’s look at the most common invasive devices used to assess hemodynamic status—arterial lines, central venous pressure catheters, and pulmonary artery catheters.

Arterial lines are a low-risk, reliable method for continuously monitoring systemic arterial blood pressure. They allow serial blood sampling, which eliminates repeated painful arterial needle sticks for arterial blood gas (ABG) evaluations. They can also evaluate the high-pressure blood flow pulsations generated by contraction of the heart, converting the pulsations to a distinctive waveform on the monitor. This should correlate with the patient’s electrocardiogram.

A peripheral infusion catheter is inserted into an easily accessible artery, such as the radial, brachial, or femoral artery, after arterial blood flow to the extremity is verified. The catheter is secured by sutures or a sterile securement device. Because arterial lines are vascular access devices, they require the same nursing care provided to any central catheter, such as sterile dressing changes and flush bag and tubing changes every 72 to 96 hours.

The most frequent complication of arterial lines is thrombosis. Because the risk of thrombosis increases the longer the arterial line remains in place, the insertion site is rotated every 72 to 96 hours at many institutions. The usual rate of catheter-related bloodstream infections from a radially placed arterial line is 1% to 2%. Infection rates rise when a cut-down insertion technique is used for sites other than the radial artery—the most common site for an arterial line insertion—and with previous infection from other sources.

Other potential complications include skin breakdown under the transducer set at the catheter hub, excessive bleeding from the insertion site or from the system itself if the line is disconnected, air embolism from purging air into the patient, and ischemia distal to the insertion site, should arterial flow become compromised.

The pressure’s on
The central venous pressure (CVP) is a measurement of the pressure in the right atrium, which reflects the relationship among cardiac action, vascular tone, and blood volume. CVP isn’t an accurate reflection of left ventricular function, though.

CVP is usually measured in patients for whom fluid balance is a concern. On the basis of the CVP readings, the health care provider can make more accurate decisions about fluid replacement or restriction. The normal CVP reading is to 2 to 6 mm Hg. Decreased CVP indicates low circulating volume; elevated CVP indicates fluid overload.

A single- or multilumen CVP catheter may be inserted through the internal jugular or subclavian vein, with the tip advanced into the superior vena cava. A CVP inserted into the femoral vein resides in the inferior vena cava.

The pressure monitoring assembly is usually attached to the distal port of a multilumen central venous catheter. Other lumens may be used for rapid infusion for fluid replacement in shock, infusion of hypertonic solutions and medications that could damage veins, and serial venous blood assessment.

Follow your institution’s policy for sterile CVP line care, including flushing and dressing changes. Unused lumens must be flushed at manufacturer-recommended intervals to avoid thrombotic complications, which can lead to catheter-related bloodstream infection. Temporary central venous catheters have the highest risk of catheter-related bloodstream infection, so keep the system closed and change dressings, caps, and tubings at the recommended intervals. Sterile techniques must be used for CVP line care.

Never tie off clotted lumens; a clot is a breeding ground for bacteria. Clear the lumen with an approved thrombolytic agent (such as alteplase [Cathflo Activase]) or exchange the catheter; remove the catheter if it’s no longer needed.

Other potential complications of CVP lines include pneumothorax (on insertion), excessive bleeding, arterial puncture,
catheter malposition, cardiac tamponade, cardiac arrhythmias, deep vein thrombosis, air embolism, and catheter embolism.

As you remove the CVP line, don’t cut the catheter when taking out the sutures. Have a sterile, occlusive, pressure dressing ready to cover the site to prevent excessive bleeding and air embolism. Ask the patient to “bear down” while you remove the catheter. You can also remove the catheter as the patient exhales. Depending on your institution’s policy, you might use petrolatum gauze or apply antimicrobial ointment to the dressing to seal the catheter tract.

Let’s multitask!
The pulmonary artery (PA) catheter has several functions, including measuring CVP, measuring pressure in the pulmonary artery, and reflecting the pressure in the left atrium. It also allows for hemodynamic calculations, such as cardiac output.

Routine use of PA lines is controversial because of associated risks and costs. Many opponents believe the lines should be reserved for the most critically ill patients.

Typically, PA lines are inserted through a single-lumen introducer placed in the internal jugular or subclavian vein. The PA catheter slides through the introducer diaphragm, then is threaded through the right atrium and right ventricle and into the pulmonary artery. The introducer diaphragm prevents air from getting into the bloodstream.

A league of their own
PA lines are longer and have more ports than other types of CVP lines. A small balloon at the tip of the catheter can be inflated to allow pressure measurements within the pulmonary artery, which reflects the pressure in the left atrium of the heart.

In some cases, two transducers are set up for a PA line. One transducer may be hooked to the right atrial port for continuous CVP monitoring; the other is connected to the distal port to read pressures in the pulmonary artery. A small syringe is attached to one port, and it’s used to inflate the balloon. This is done only to allow the tip of the catheter to float from the pulmonary artery into a pulmonary capillary, known as “wedging” the pressure. When the catheter tip goes as far as it can, pulmonary capillary wedge pressure (PCWP) can be measured. The PCWP reflects the pressure within the left atrium. The balloon is deflated as soon as PCWP is obtained. Look at the number and waveform to make sure the catheter isn’t still wedged. The pressures measured by the PA catheter can be used for other hemodynamic calculations, such as systemic vascular resistance (SVR) and cardiac index (CI).

Another feature of the PA catheter is a crinkly, plastic sheath that covers a portion of the external catheter. This sheath maintains sterility of the catheter as it’s advanced through the heart, so it shouldn’t be removed. At most institutions, the catheter can’t be advanced after the first 24 hours following insertion. Chest X-rays must be done to verify PA catheter placement and to ensure that the patient doesn’t have a pneumothorax.

Like other central catheters, the PA line must be covered with a sterile dressing according to your institution’s protocol. The dressing, all caps applied to the catheter lumens, and the pressure monitoring setups must be replaced at the intervals specified by your institution’s policy. Your institution may follow the Centers for Disease Control and Prevention’s guidelines, which recommend that tubing be replaced every 96 hours. Although you may be tempted, don’t pin or tape the PA line to your patient’s gown in an effort to prevent its accidental dislodgment. The patient could end up pulling on the line as he moves.

Pulling into port
PA catheters have several lumens. Knowing the function of each port can be confusing. Here’s a rundown:

- distal port: used for monitoring the PA pressures
- proximal port: used for monitoring CVP, administering intermittent medications like antibiotics, and for I.V. push medications.
Use this port for pushing drugs in a code; it allows for the best hemodilution within the central venous system. If the PA catheter has white and purple ports (VIP ports), use them for continuous infusions of fluid or medications. It’s always a good idea to save one port for total parenteral nutrition—and flag it with tape—in case the patient can’t take nutrition enterally. All unused ports should be flushed according to your institution’s policy.

Patients with multilumen catheters, such as PA catheters, are vulnerable to infection. Other potential complications include pneumothorax, hemothorax, cardiac arrhythmias (especially in patients with abnormal potassium and magnesium levels as the catheter is advanced through the right ventricle), air embolism, pulmonary artery rupture, balloon rupture (blood backflows into the syringe), and catheter malposition.

**Armed with information**

Now that you’ve read this article, you should better understand that tangle of “spaghetti” attached to your critically ill patient. In most cases, specially prepared nurses will monitor hemodynamic catheters. But if your patient is being moved to the intensive care unit, it’s helpful for you to know the purpose of these lines and to be able to tell your patient what to expect.

**References**

