noninvasive oscillometric method actually measures MAP and calculates systolic and diastolic pressures. The invasive method calculates MAP from the area under the curve of the arterial waveform (Figure 1).

In a perfect world, the two MAPs are relatively close, within 10 mm Hg. In reality, many technical, operator, and patient-related factors contribute to inaccuracies with either method. You must exercise considerable clinical judgment and understand the limitations of both methods to puzzle out whether one, the other, or neither measurement accurately captures your patient's hemodynamic status.

Most nursing literature recommends using the invasive arterial pressure for clinical decisions, as long as it is set up properly, has good waveforms and passes the “square wave test.” With the square wave test, the hydraulic system is opened to the pressurized flush for a few seconds, then quickly closed. The monitor tracing should shoot up to its maximum, sharply flatten out, and as sharply fall back to a little below baseline, then rebound up and down in quickly attenuating waveforms until returning to normal.

The normal arterial pressure waveform has several sections: rapidly increasing tracing up to a peak, then dropping down to a “shoulder” called the dicrotic notch, then somewhat less rapid declining to baseline or until the next cycle. The dicrotic notch represents closure of the aortic valve. The time from beginning of the upstroke to the dicrotic notch reflects the entire systolic period. The peak of the tracing is often read by the monitor as the systolic pressure, and the lowest point of the tracing is read as diastolic. The entire area under this curve is the MAP.

All waves or vibrations have a natural resonant frequency (RF). Additional energy applied to the waves at or near that frequency will dramatically increase the size of the waves. Peripheral arterial waveforms have a natural RF of about 3 to 5 Hz. If the fluid-filled hydraulic system also vibrated at 3 to 5 Hz, the result would be an overexcited or augmented waveform pounding on the silicon chip and causing amplification or “ringing” in the electrical tracing. The peak of the tracing would be much higher than the actual pressure inside the artery, or “systolic overshoot” (Figure 2). This can lead to incorrect assumptions of hypertension and physiologically inappropriate treatment. So, the hydraulic system has an RF of 10 to 20 Hz, at least three to four times the physiologic RF. In patients whose RF is higher, a damping device can be added to the system to reduce the vibrations and overshoot.

Hydraulic systems can be overdamped too. Compliant or excessive tubing, air bubbles, catheter malposition, an underpressurized system and other factors may greatly reduce the vibrations reaching the transducer, creating a flattened waveform that does not reflect the patient’s pressures (Figure 3). A waveform that appears to indicate hypotension may result in inappropriate fluid challenges and vasopressors. In such a case, the cuff pressure may be higher than the arterial pressure, a clue that the system is overdamped.

Interpreting an “art line” pressure takes considerable skill and an understanding of the physiology, physics and physical setup that produce the numbers. Frequently, the physician must base his or her estimate of the true blood pressure on clinical judgment, and not rely so heavily on the numbers.

**Figure 3. Overdamped.** Sluggish return to baseline with poor arterial tracing.

---

**Dr. Kirkland is a hospitalist at the Mayo Clinic in Rochester, Minn., and a critical care specialist at Abbott Northwestern Hospital in Minneapolis. She is a member of ACP Hospitalist’s editorial advisory board.**