Monitoring the systemic circulation

Azmy R. Boutros, M.D.

Cleveland, Ohio

Optimizing systemic circulation involves the maintenance of optimal cardiac output and tissue perfusion without unfavorable effects on coronary blood flow or the critical balance between myocardial oxygen supply and demand.[1]

Direct measurement of arterial pressure[2]

A well-reproduced signal can yield valuable information relevant to the status of systemic circulation. Systolic, diastolic, and mean arterial pressures are important determinants of flow and tissue perfusion. Rate of rise of pressure in the arterial pressure wave form is an indirect indicator of myocardial contractility. The position of dicrotic wave takeoff could provide information relevant to the volemic status of the patient. Hypovolemia is often associated with low takeoff of dicrotic wave.

Fidelity of reproduction of arterial pressure signal is important for appropriate interpretation of the significance of the measurement. The most important factors affecting the quality of the signal are catheters used for cannulation, conducting systems of extension tubing and stopcocks, and the disposable diaphragm domes. With a reasonable conducting system, a frequency response of 6 to 20 Hz is adequate for reasonable reproduction of a signal. Resonance and overshoot are due to underdamping

of the signal and can result in inaccuracies. Several measures are used to diminish underdamping although none are totally dependable.

Myocardial oxygen consumption

Heart rate and systolic pressure significantly correlate with myocardial oxygen consumption. Rate-systolic pressure product shows more significant correlation with myocardial oxygen consumption in awake and anesthetized patients.[3] ST-segment changes especially in lead V-5 could be useful indicators of myocardial oxygen consumption.[4]

Tissue perfusion

Clinical indicators of tissue perfusion, e.g., color, temperature of the skin, capillary refill, and size of the pupil continue to provide excellent information to the clinician. Adequate urine output in the absence of renal failure is indicative of a reasonable level of renal perfusion. Figures for optimal hourly urine output vary. There are no hard data to support the assumption that urine output need be higher than 30 to 40 ml/hr.

Mixed venous blood data are useful indicators of tissue perfusion. With low flow states, oxygen extraction increases leading to lowering of oxygen content of mixed venous blood. This could be documented by measuring mixed venous oxygen tension, mixed venous oxygen saturation, or mixed venous oxygen content. Mixed venous oxygen tension measurement is easier but less sensitive than mixed venous oxygen saturation or mixed venous oxygen content measurement.

Monitoring of systemic circulation during bypass

Mean arterial pressure obtained with nonpulsatile flow is often assumed to be the major determinant of tissue perfusion. Inaccuracies due to peripheral arterial spasm or Venturi effect in the aortic arch due to flow through the aortic cannula may result in artificially low mean pressure readings. Some centers rely more on pump flow rates to define tissue perfusion. Mixed venous oxygen saturation or content acquire added importance as indicators of tissue perfusion while the patient is on bypass.

References

1. Gilbert BW, Hew EM. Physiologic significance of hemodynamic measurements and their derived indices. Can Med Assoc J 1979; **121:** 871–6.
2.. Morton BC. Basic equipment requirements for hemodynamic monitoring. Can Med Assoc J 1979; **121:** 879–85.
3. Wilkinson PL, Moyers JR, Ports T, Chatterjee K, Ullyott D, Hamilton WK. Rate-pressure product and myocardial oxygen consumption during surgery for coronary artery bypass. Circulation 1979; **60** (suppl I): I-170–I-173.
4. Ross J Jr. Electrocardiographic ST-segment analysis in the characterization of myocardial ischemia and infarction. Circulation 1976; **53** (suppl I): I-73–I-81.