Q & A

Hemostasis During Open-Heart Surgery

In what ways does cardiopulmonary bypass affect hemostasis?

Many variables may contribute to bleeding complications of patients undergoing cardiopulmonary bypass (CPB). The equipment, surgical techniques, and operative protocol vary greatly among hospitals, while patients have a variety of preoperative conditions and take different medications. These variables affect hemostasis. Features common to most CPB surgeries, such as hemodilution, hypothermia, synthetic surfaces, and pharmacologic agents, also disrupt the normal hemostatic mechanisms.

The goal of CPB is to provide a motionless, bloodless heart for the cardiac surgeon. This is accomplished by temporarily diverting the blood flow from the heart and lungs to the perfusion circuitry, which consists primarily of a pump and an oxygenator, which are hooked together with plastic tubing. Use of these devices, along with others, allow respiration, ventilation, circulation, and temperature regulation of the patient's body to be accomplished.

The patient's blood is diverted to the heart-lung machine and perfusion circuitry by way of cannulae. The venous cannula is inserted into the right atrium for gravity drainage from the patient. The arterial cannula returns oxygenated blood and usually is placed in the ascending aorta. The cannulae and perfusion circuitry are primed with about 1.5 to 2 L of electrolyte-balanced solutions that eventually will mix with the patient's blood. This solution, along with the solutions administered by anesthesia (such as fluids to maintain safe volume levels and blood pressure), will dilute the hematocrit, platelet count, and coagulation proteins. Sometimes, red blood cells, albumin, hetastarch (a synthetic plasma-volume expander), or other volume expanders are added. Dilutional effects of CPB commonly result in hematocrit values in the low to mid 20s and a 50% dilution of the patient's own blood. In uncomplicated surgeries, this does not cause bleeding complications.1 During CPB, a urine output of greater than 1 mL/kg/hr indicates that other vital organs are being well perfused.2 Diuresis in the immediate postoperative period will eliminate excess water, thereby concentrating the patient's hemoglobin level.

Before cannulae are inserted, the patient is anticoagulated with a massive amount of heparin. After prolonged clotting status is established, the cannulae and fluid-filled tubing are connected, and CPB is begun. The blood flow to the patient is constant and generally nonpulsatile.

Within minutes, the patient's blood becomes mixed and diluted with the priming solution as it passes over a tremendous amount of foreign surface area. More cannulae are inserted into the heart, and the patient then is cooled to decrease metabolism and oxygen requirements. Requirements vary, but lowering the patient's temperature to 28°C to 30°C is standard. For every 1°C that the temperature is decreased, the metabolic rate will decrease by 7%, or 50% for every 7°C.3 Hemodilution becomes a benefit...
because better tissue perfusion occurs with lower hematocrits. A cold cardioplegic solution, which contains potassium chloride concentrations of 15 to 30 mEq/L, is delivered to the heart to arrest it in diastole. Potassium values may temporarily range from 6.0 to 7.0 mEq/L. The potassium level is monitored and should return to acceptable levels by the end of the surgery. However, if the level remains elevated, it may need to be treated.

Approximately 70% of circulating platelets disappear as soon as bypass begins, and most of these are sequestered in the liver. Platelets become activated and temporarily dysfunctional. The causes of platelet dysfunction include contact with synthetic surfaces, hypothermia, and possibly heparin. Platelet function returns to normal within 2 to 4 hours after bypass. Plasma proteins quickly adsorb onto the synthetic surfaces of the perfusion circuit. Notably, fibrinogen will also adsorb and provide binding sites to which platelets adhere.

Before the surgery is complete, the patient is rewarmed. Metabolism resumes and various parameters are monitored closely. The blood gases, glucose, and electrolytes are corrected before terminating CPB. Once off bypass, protamine is used to reverse heparin.

Certain pharmacologic agents may contribute to the bleeding risk, particularly aspirin or coumarin drugs. Streptokinase, urokinase, tissue plasminogen activator or platelet inhibitors may have been administered in the immediate preoperative period. Thus, the patient’s medications must be taken into account in assessing the overall bleeding risk.

References