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CRITICAL CARE MEDICINE BOARD REVIEW MANUAL

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Monitoring in the Intensive Care Unit

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Monitoring in the Intensive Care Unit

Dany A. Obeid, MD, and Hector R. Cajigas, MD

INTRODUCTION

Current management of critically ill patients in the intensive care unit (ICU) requires ample knowledge of monitoring devices employed in this setting. Physicians must understand the technical aspects of monitoring devices (eg, insertion and maintenance) and clinical issues around their use (indications, complications) and be able to interpret and apply the data they provide. Although monitoring systems have become increasingly more complex, the basic principles and components of good monitoring in the ICU remain unchanged. This manual discusses the most commonly used devices in the ICU, including pulmonary artery catheters (PAC), arterial catheters, intracranial pressure (ICP) monitors, and capnography.

PULMONARY ARTERY CATHETERIZATION

The PAC was first described by Swan et al in 1970.¹ Since its introduction, the PAC has made a significant impact on bedside monitoring of patients' hemodynamic status by providing direct measurements of vascular pressures, including central venous, right-sided intracardiac, pulmonary artery, and pulmonary artery wedge pressures.

The PAC is 110 cm long and has an outside diameter of 2.3 mm (7 Fr) (**Figure 1**). The catheter has a balloon at its tip with a maximum capacity of 1.5 mL that is used for "flow directing" the catheter through the heart into a branch of the pulmonary artery. The catheter has 2 ports: a distal port at the tip of the catheter that opens to pulmonary artery lumen and a proximal port located 30 cm from the tip that opens to the right atrium. A thermistor located 4 cm from the tip is used to calculate cardiac output. An extra channel located 14 cm from the tip is used for infusions and for inserting temporary pacemaker leads into the right ventricle. A fiberoptic system allows the oxygen content of mixed venous blood to be continuously determined via the distal port, and a thermal filament can be used for continuous determination of cardiac output. A

large-bore introducer catheter is used to insert the PAC.

INDICATIONS AND COMPLICATIONS

There are diagnostic and therapeutic indications for pulmonary artery catheterization. Monitoring with a PAC can be used to diagnose different types of shock, pulmonary edema, cardiac tamponade, acute mitral regurgitation, and constrictive pericarditis and to evaluate for such conditions as pulmonary hypertension and left-to-right intracardiac shunts.² Therapeutic indications include guiding therapy for patients with shock, fluid management, management of high-risk patients perioperatively, and management of patients with heart failure and following cardiac surgery. Because no study has demonstrated improved outcome with use of PAC monitoring, all indications are based on expert opinion.²⁻⁵

Absolute contraindications to pulmonary artery catheterization include tricuspid or pulmonary valve mechanical prosthesis/stenosis, right heart mass (thrombus and/or tumor), cyanotic congenital heart disease (specifically, tetralogy of Fallot), latex allergy (latex-free catheters are available), and previous pneumonectomy. In patients with pneumonectomy, pulmonary artery rupture is lethal, and balloon inflation may cause a severe rise in pulmonary vascular resistance. Relative contraindications include risk for arrhythmias, anticoagulation, proposed pneumonectomy, and cardiopulmonary bypass surgery.

Complications associated with pulmonary artery catheterization are divided into 3 types: those related to vascular access, insertion of the PAC, and maintenance of the catheter.⁶⁻⁸ Vascular access complications include arterial puncture (2%–16%), pneumothorax (2%–4%), and tension pneumothorax. Insertion of the catheter is complicated mainly by arrhythmias, most of which are premature ventricular beats or nonsustained ventricular tachycardia. Patients with cardiac disease are at risk of serious ventricular tachycardia or ventricular fibrillation (< 1%). Right bundle branch block can develop in approximately 5% of patients who undergo catheter insertion. This complication can be significant in patients with preexisting left bundle branch block by placing the patient at risk for complete heart block. In patients with