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Pulmonary artery catheter

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Since its inception, the pulmonary artery catheter has enjoyed widespread use in both medical and surgical critically ill patients. It has also endured criticism and skepticism about its benefit in these patient populations. By providing information such as cardiac output, mixed venous oxygen saturation, and intracardiac pressures, the pulmonary artery catheter may improve care of the most complex critically ill patients in the intensive care unit and the operating room. With its ability to transduce pressures through multiple ports, one of the primary clinical uses for pulmonary artery catheters is real-time intracardiac pressure monitoring. Correct interpretation of the waveforms is essential to confirming correct placement of the catheter to ensure accurate data are recorded. Major complications related to catheter placement are infrequent, but misinterpretation of monitored data is not uncommon and has led many to question the utility of the pulmonary artery catheter. The evidence to date suggests that the use of the catheter does not change mortality in many critically ill patients and may expose these patients to a higher rate of complications. However,

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additional clinical trials are needed, particularly in the most complex critically ill patients, who have generally been excluded from many of the research trials performed to date.

Evolution of the pulmonary artery catheter

Since its inception, the pulmonary artery catheter (PAC) has enjoyed widespread use in both medical and surgical critically ill patients. It has also endured criticism and skepticism about its benefit in these patient populations. The PAC is used to aid in diagnosing and treating the complex nature of cardiopulmonary derangements in patients with critical illness. It also helps to guide the anesthesiologist or intensivist in the treatment of the most critically ill patients who present to the operating room and the intensive care unit (ICU). By providing accurate measurements of a wide range of cardiovascular variables such as cardiac output (CO), mixed venous oxygen saturation, and intracardiac pressures, the PAC may improve care of our most complex and hemodynamically unstable patients.

The idea of right heart catheterization dates back to 1929 when Dr. Werner Forssmann placed a urethral catheter through his own vein to measure pressures in his right heart chambers. The technique progressed further in 1944 when Cournand and Lauson published their recordings of right heart pressures. In 1954, Connolly and colleagues demonstrated that pulmonary artery wedge pressures (PAWPs) correlated closely with left atrial pressures (LAPs), thus further expanding the role of heart catheterization. Forssmann, Cournand, and Richards were awarded the Nobel Prize in Medicine in 1956 for their work with the PAC [1].

Right heart catheterization remained a procedure performed only in the cardiac catheterization laboratory with stiff catheters that could not remain in place for long periods until 1970, when Drs. Swan and Ganz introduced the flow-directed balloon-tipped catheter, which could be placed at the bedside without the use of fluoroscopy. The idea of balloon floatation is said to have come to Dr. Swan while he was watching boats in the Santa Monica Bay, advancing downwind with their spinnakers filled. He believed that by adding a balloon tip, the catheter would be carried into the PA by the continuous blood flow. Dr. Swan and Dr. Ganz published a case series of 100 patients in which they successfully placed the catheter in 60 patients without the use of fluoroscopy [2,3]. They also showed that catheterization was completed far faster than traditional placement without the aid of the balloon-tipped catheter. One of the most significant advantages of the so-called Swan–Ganz catheter was that it could be left in place for days at a time, because the balloon tip was mounted on a flexible catheter, which was theoretically less traumatic than traditional stiffer cardiac catheters. With the balloon deflated, the PAC could remain in place for prolonged periods of patient monitoring without obstructing flow through the PA. The catheter was further modified to enable measurement of all right-sided pressures, PAWP, thermodilution CO, continuous mixed venous oxygen saturation [4], and pacing of the right atrium (RA) and right ventricle (RV).

Clinical use and practical applications

With the ability to transduce pressures through multiple ports, PACs provide intracardiac pressure monitoring at several right heart sites in real time (Fig. 1). When the PAC is in a proper position with its tip in the PA, the central venous pressure (CVP) orifice, which lies 30 cm from the tip of the catheter, records the right atrial pressure (equal to CVP), while the orifice at the distal tip of the catheter measures the pulmonary artery pressure (PAP). One must use caution in assuming the location of the PAC tip resides in the PA, because in the operating room, PACs are frequently inserted partially to a more proximal location for surgical procedures involving the right side of the heart (tricuspid valve, pulmonic valve surgery, or heart transplantation). In these situations, the distal port records CVP rather than PAP.