Inadvertent Passage of a Pulmonary Artery Catheter from the Superior Vena Cava Through the Left Atrium and Left Ventricle into the Aorta

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Pulmonary artery catheters are frequently used for hemodynamic monitoring during cardiac surgical procedures. We report a case in which a pulmonary artery catheter passed through a surgically repaired tear in the superior vena cava (SVC) into the left atrium (LA), through the left ventricle (LV), and subsequently into the aorta. The failure to recognize this immediately led to erroneous conclusions that potentially could have compromised the patient's care.

REPORT OF A CASE

A 74-yr-old female with rheumatic heart disease, who had undergone open mitral commissurotomy for mitral valve stenosis 11 yr previously, presented to Massachusetts General Hospital with recurrent mitral stenosis, and mitral regurgitation. She had done well until the recent development of increasing dyspnea-on-exertion, ascites, and peripheral edema.

Cardiac catheterization revealed: cardiac output 3.41 \( \text{min}^{-1} \), stroke volume 52 ml, left ventricular pressure 135/15 mmHg, right ventricular pressure 85/12 mmHg, pulmonary artery pressure 85/30 mmHg, mean pulmonary capillary wedge pressure 25 mmHg with V waves to 35 mmHg, and mean right atrial pressure 9 mmHg with V waves to 12 mmHg. Mitral valve area was calculated to be 0.88 cm\(^2\). Left ventriculography demonstrated severe mitral regurgitation and mild aortic insufficiency. Coronary angiography demonstrated normal coronary arteries.

The patient was premedicated with morphine 5 mg im and scopolamine 0.3 mg im. Fourteen-gauge intravenous catheters were inserted in both arms and a 20-gauge arterial catheter was inserted in the right radial artery. Continuous electrocardiography and pulse oximetry were employed. A pulmonary artery catheter was inserted via the right internal jugular vein without difficulty, and a pulmonary capillary wedge pressure tracing was obtained at 45 cm.

Anesthesia was induced with fentanyl 5 mg iv, muscle paralysis obtained with vecuronium 10 mg iv, and the trachea was intubated. Hemodynamics were stable in the preperfusion period and cardiopulmonary bypass was instituted. At the beginning of cardiopulmonary bypass, the SVC, which was fixed by adhesions from the previous surgical procedure, was torn during the attempt to place a tape around it. The pulmonary artery catheter was removed in order to decrease the chance of trapping the catheter when closing the tear. The tear in the posterior right side of the SVC was repaired with mattress sutures, which were buttressed by passing them through the adjacent pericardium. The left atrium was then opened along its previous suture line and mitral valve replacement was performed using a 27-mm St. Jude Medical bileaflet prosthesis. Closure of the left atrium was technically difficult, as the previous incision had been well out onto the right superior pulmonary vein, which was dilated, thin walled, and fixed by dense adhesions and scar tissue. In closing the left atrium, the lateral pericardium was incorporated into the closure of the atriotomy as an in situ flap to enlarge the atrium and avoid tension on the suture line.

Because of the patient's pulmonary hypertension, at this point an attempt was made to pass a pulmonary artery catheter from the left femoral vein to facilitate separation from bypass and postoperative management. The left femoral vessels had been exposed prior to the chest incision in case urgent institution of cardiopulmonary bypass had proven necessary. The catheter could only be advanced as far as the right ventricle. Right ventricular pressures were thus used to guide separation from cardiopulmonary bypass, which was accomplished with the aid of dopamine (5 \( \mu g \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \)) and calcium chloride 1 g iv. The patient was hemodynamically stable after cardiopulmonary bypass (fig. 1) with a right ventricular pressure of 50 mmHg. A large intravascular volume requirement persisted, however, which continued after chest closure and necessitated transfusion of multiple blood products.

While deciding whether to reexplore the chest for bleeding, the left femoral catheter was removed from the right ventricle and an introducer percutaneously inserted into the right external jugular vein (it was elected not to pass another catheter through the existing introducer in the patient's right internal jugular vein because of the hazard of infection with a prosthetic valve). Several unsuccessful attempts were made to pass the catheter into the right ventricle, with the catheter each time appearing to kink. The possibility that the catheter was passing distally in the subclavian vein was considered. The catheter was then withdrawn to the 25-cm mark and passed with the balloon deflated, without resistance, until a ventricular pressure trace was seen. The balloon was then inflated and the catheter advanced. In an attempt to obtain a pulmonary capillary wedge tracing, the catheter was advanced to 50 cm. This was unsuccessful. The balloon was deflated and the catheter withdrawn to 40 cm, where the proximal and distal ports
FIG. 1. Electrocardiographic and pressure tracings showing hemodynamic monitoring during initial separation from cardiopulmonary bypass. The tip of the pulmonary artery catheter is in the right ventricle, as it was not possible to pass it into the pulmonary artery.

Several attempts to obtain cardiac outputs by thermodilution using an Edwards 9502 cardiac output computer yielded results of 0.01 Λ/min⁻¹. Of concern was the fact that the pulmonary artery systolic pressure, measured at the distal port of the catheter, had increased to approximately 90–100 mmHg. This increase was attributed to the multiple blood components that had been administered.

A decision was then made to reexplore the chest to achieve hemostasis. The incision was reopened and the left atriotomy was found to be the site of the bleeding. At this point, the surgeon was asked to palpate the pulmonary artery to confirm the degree of pulmonary hypertension. The surgeon felt that the PA pressures were not as high as reported (approximately 80/50 mmHg), and, in fact, was unable to palpate the catheter in the pulmonary artery. The similarity of the radial arterial and “pulmonary artery” tracings was then appreciated. Cardiopulmonary bypass was re instituted. Upon reopening the left atriotomy, the pulmonary artery catheter was seen passing through the repair in the posterolateral aspect of the SVC, and into the enlarged left atrial chamber, which had been created by incorporation of the lateral pericardium in the atriotomy closure. The catheter had then passed through the mitral prosthesis into the LV and out the aorta. The catheter was withdrawn into the SVC. The LA was closed primarily and the patient again separated from cardiopulmonary bypass using central venous and left atrial pressure monitoring. Several further attempts were made to readvance the catheter into the right atrium prior to chest closure without success. After chest closure, a pulmonary artery catheter was inserted with some difficulty via the right femoral vein. This demonstrated that the pulmonary arterial pressure was approximately one-half of the systemic pressure. The patient was then transported to the intensive care unit.

DISCUSSION

Several studies on the use and complications of pulmonary artery catheterization have been published, but none have reported passage of a catheter in a manner similar to that described above. The surgical procedure in this case resulted in a suture line in the SVC. The difficulty in passing the catheter into the right atrium may have been related to narrowing of the SVC by the surgical repair. The catheter with the balloon deflated passed through this suture line into the LA, which had been enlarged by incorporating the adjacent pericardium into the atriotomy closure. The catheter then passed into the LV and out into the aorta. Although this was not recognized until the surgeon noted the absence of the catheter in the pulmonary artery and the discrepancy between the monitored PA pressure and that which was estimated by palpation, there were several clues that could have alerted us that the catheter had passed into the aorta.

First, an abrupt 30 mmHg decrease of systemic pressure without a change in heart rhythm occurred when the catheter passed into the ventricle. This is suggestive of incomplete closure of the mitral prosthesis. Second, when the pressure tracings were examined carefully, it became clear that the “pulmonary artery” pressure (which was really aortic pressure) and the radial artery pressure were virtually identical. Third, there was an apparent doubling of “right” ventricular pressure from 50 to 100 mmHg during the period of 30 min between removal of one catheter and placement of another. The pulmonary artery catheter that had been passed via the left femoral vein into the right ventricle had been removed at the time of closure of the left groin incision. The right ventricular pressure had been stable and it was expected that passage of a new pulmonary artery catheter from the neck would not be difficult. Thus, we did not have simultaneous measurements of right and left ventricular pressures. Our expectation of severe pulmonary hypertension due to preoperative pulmonary hypertension and the administration of multiple blood transfusions also misled us. Fourth, the pressure tracing recorded at the proximal port demonstrated a tracing of mitral regurgitation when the catheter was advanced from the LA to the LV. We erroneously
interpreted this as a right ventricular tracing, not considering that the pressure amplification had been changed. We drew the wrong inference despite peak pressures of the regurgitant wave that were only 35 mmHg and an upstroke that was not as brisk as expected. This was attributed to catheter damping. Fifth, the inability to obtain a cardiac output measurement with injection of thermal indicator could have alerted us to the possibility of catheter misplacement. However, that is a nonspecific finding. Recording of the thermodilution curve might have made us more suspicious. We could have confirmed systemic placement by analysis of a blood sample drawn from the distal catheter port. A fiberoptic oxygen saturation catheter would certainly have caused us to consider this possibility.

A major hazard of left sided placement of a pulmonary artery catheter is systemic embolization. This may be particularly likely with injection of crystalloid solutions while attempting to measure cardiac output. Fortunately, this patient suffered no complications indicating such an occurrence.

In summary, a catheter introduced via the right internal jugular vein passed through suture lines in the SVC and LA into the LV and aorta. This was not immediately recognized, despite a number of findings which, in retrospect, provided clues to the aberrant placement. Attention to such findings could enable earlier detection in case this rare event occurs again.

REFERENCES