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A Curious Case of a Catheter Looped in the Left Main Pulmonary Artery

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1. Abstract

Pulmonary Artery Catheters (PACs) have been utilized in the critical care and perioperative settings to guide fluid resuscitation and titration of vasopressors and inotropes for several decades. Placement of PACs are not without difficulty. One known complication is the distal portion of the catheter looping in the superior vena cava, right heart, or more rarely in the main pulmonary artery. We present a novel case where the PA catheter coiled in the left main pulmonary artery.

2. Case Presentation

Our patient was a 33 year old gentleman who presented a week prior for a stab wound to the right chest. A median sternotomy was performed at the time, which revealed no signs of cardiac injury and he was discharged home. He re-presented to the hospital several days later, complaining of persistent chest pain and shortness of breath. Echocardiogram revealed pericardial effusion with tamponade physiology. He received a pericardiocentesis with drain placement. However, his effusion continued to worsen with poor drain output, and he was brought to the OR by the cardiothoracic surgery team for a pericardial window.

Our anesthetic plan for this patient with evolving cardiac tamponade included PA catheter placement to closely monitor pulmonary pressures and cardiac output. After induction, we placed a Cordis central line into the right internal jugular vein without complication. Afterwards, we threaded a PA catheter through the Cordis introducer. The catheter was easily advanced to 55cm until the appropriate PA waveform was observed. Pulmonary pressures were slightly elevated, which was expected based on patient's tamponade physiology. However, the calculated values of Cardiac Output (CO) and Cardiac Index (CI) were noted to be abnormally high at 8.2 L/min and 3.3 L/min/m2, respectively. Transesophageal Echocardiogram (TEE) exam showed the distal portion of the catheter looped on itself in the left pulmonary artery. This was confirmed with chest X-ray taken at the end of the case. The PA catheter was then removed without incidence (Figure 1, 2).

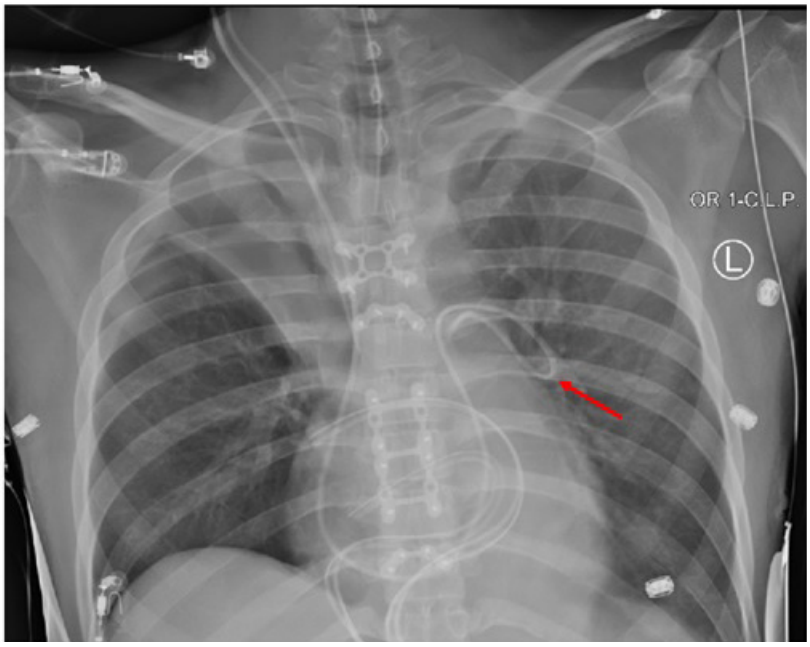

Figure 1: Portable chest x-ray of malpositioned PA catheter. Red arrow denotes distal portion of catheter seemingly looped in the left pulmonary artery.

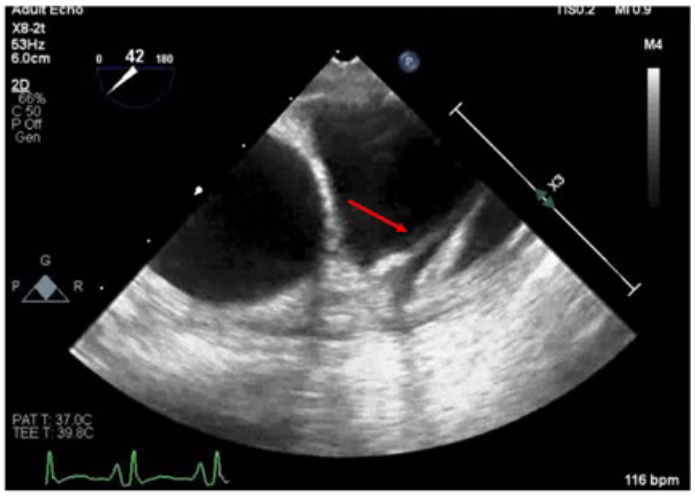

Figure 2: TEE short axis view of left pulmonary artery. Red arrow denotes two looped distal segments of the PAC.

3. Discussion

Since its introduction in the 1970s, the pulmonary artery catheter has been widely used in perioperative setting, particularly for patients with cardiovascular derangements undergoing open cardiothoracic surgery. Real-time measurements of PA pressures, SvO2 and cardiac index have been invaluable for titrating appropriate hemodynamic therapies for critically ill patients. However, the placement of PAC entails certain complications. The incidence of the catheter looping is low, ranging from 0.2% to 2.5%. The most frequent sites include the superior vena cava, right atrium or right ventricle. More rarely, there have been documented cases of the PAC looping in the main pulmonary artery. To the best of our knowledge, this is the first reported case of coiling in the left pulmonary artery.

The inaccurately high cardiac output and index stems from how the PAC calculates hemodynamic values. Older models of PA catheters calculated cardiac output utilized the Fick principle. It is demonstrated by the Fick equation, which uses total body oxygen consumption (VO_2) and oxygen content of arterial blood $(CaCO_2)$ and venous blood $(CvCO_2)$:

$$CO = \frac{VO_2}{CaCO_2 - CvCO_2}$$

Cardiac output would be calculated by analyzing oxygen content of arterial and venous blood, and VO2 calculated by measuring expired air (Figure 3,4).

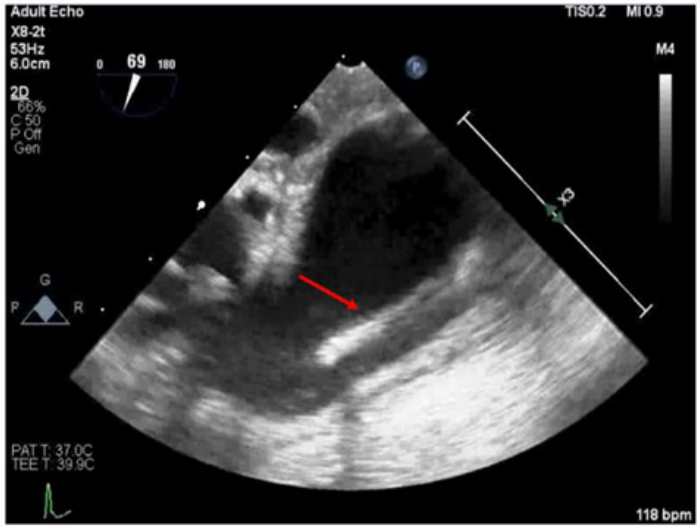

Figure 3: Another TEE view with a more oblique, omniplaned cross section of the left PA. Red arrow denotes the looped PAC.

Figure 4: Long axis view of pulmonary artery and short axis view of ascending aorta. Red arrow denotes looped PAC.

Newer generations of PA catheters apply the thermodilution method to calculate CO and CI. The tip of the catheter in the pulmonary artery has a thermistor tip. At the end of expiration, a cold saline solution of fixed temperature and volume is injected into the right atrium via a proximal port of the PAC. The cold solution mixes with blood passing through the right side of the heart, where the thermofilament of the PAC to warm the solution is located. The warmed solution then passes into the pulmonary circulation and thermistor tip. The tip senses a change in temperature (thus the term thermodilution) and calculates cardiac output through the Stewart-Hamilton equation:

$$CO = \frac{V(T_B - T_I)K_1K_2}{\int T_B(t)dt}$$

where V = volume of injectate, T_B = temperature of blood, T_I= temperature of injectate, K_1 and K_2 are computational constants, and the denominator represents the rate of change in blood temperature with respect to time.

The PA catheter used in our case (Edwards Lifesciences Swan-Ganz CCOmbo, Model 746F8) computes cardiac output and index numbers using an empiric algorithm based on the Stewart-Hamilton equation. Instead of cold saline being injected, the catheter periodically warms blood entering the right atrium and ventricle with a known quantity of heat. The thermistor detects the small change in blood temperature downstream and computes an appropriate dilution curve.

This computational method gives us insight on why the readings were inaccurate. A measured cardiac output of 8.2 L/min is clearly erroneous in the setting of this patient's large effusion, which should result in a depressed cardiac output. The falsely high readings were caused by the inappropriately shortened distance between the thermofilament and thermistor tip. The misplaced PA catheter caused the thermofilament to be most likely located in the pulmonary artery instead of the right ventricle. The blood in the right atrium did not have adequate time to warm before reaching the thermofilament. As a result, the rate of increase in temperature was inaccurately slow, resulting in a lower number in the denominator of the equation and higher cardiac output.

In conclusion, this report demonstrates an interesting case of a pulmonary artery catheter coiling in the left pulmonary artery. We were able to recognize the misplaced catheter quickly because we inserted the TEE immediately after induction and intubation, and prior to central line placement. Early recognition and diagnosis via TEE in the intraoperative setting is paramount to avoid providing therapies based on falsely elevated cardiac parameters. An understanding of thermodilution and the Stewart-Hamilton equation allowed us to understand that the misplaced PAC would predictably result in erroneously high cardiac outputs.