Pulmonary artery catheter knot in a liver transplantation, a rare complication

ABSTRACT
The pulmonary artery catheter (PAC) measures hemodynamic parameters in real time, providing valuable data for the management of the critical patient. Nevertheless, its use is associated with several complications. Knot formation is a rare complication related to PAC insertion. A 51-year-old patient with complicated ethanolic liver cirrhosis underwent orthotopic liver transplantation. Invasive hemodynamic monitoring was performed using a Swan–Ganz pulmonary artery catheter (PAC) inserted through the right internal jugular vein. Chest X-ray in the immediate postoperative period showed the presence of a possible knot adjacent to the tip of the sheath in the internal jugular vein. The patient was then referred to the hemodynamics room, where, through fluoroscopy, a true knot was successfully removed after femoral vein dissection. The medical team should weigh the risk and benefit of using the PAC, taking into account the patient’s clinical conditions, the benefits, and possible complications of the procedure.

Key words: Complications, hemodynamic monitoring, pulmonary artery catheter, pulmonary artery catheter knot formation, Swan–Ganz catheter

Introduction
The pulmonary artery catheter (PAC) measures hemodynamic parameters in real time, providing valuable data for the management of the critical patient. Nevertheless, its use is associated with several complications,[1,2] which are didactically divided into those related to (a) venous access puncture, (b) catheterization, (c) permanence of the catheter, and (d) misinterpretation of the data acquired.[1,3,4] Knot formation is a rare complication related to PAC insertion.[1,5] Here we report a clinical case of knot formation during PAC insertion and discuss how to avoid it and how to treat it.

Case Report
A 51-year-old patient with ethanolic liver cirrhosis, complicated by portal hypertension, esophageal varices, and refractory ascites, underwent orthotopic liver transplantation. Following the institution’s protocol, invasive hemodynamic monitoring was performed with a Swan–Ganz pulmonary artery catheter (PAC) inserted through the right internal jugular vein. The venous puncture was performed with the aid of ultrasonography, and the introduction of the catheter was guided through the direct visualization of the central vein. Chest X-ray in the immediate postoperative period showed the presence of a possible knot adjacent to the tip of the sheath in the internal jugular vein. The patient was then referred to the hemodynamics room, where, through fluoroscopy, a true knot was successfully removed after femoral vein dissection. The medical team should weigh the risk and benefit of using the PAC, taking into account the patient’s clinical conditions, the benefits, and possible complications of the procedure.

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and intracavitary venous pressure curves. After the failure of the first attempt to position the catheter in the topography of the pulmonary artery, intense resistance was observed while returning it out of the sheath for a second attempt. The catheter was reintroduced and rotated, but the resistance to withdrawal remained the same. Thus, it was decided to avoid intraoperative manipulation of the catheter. The infusion routes remained patent, despite the impossibility of removal and positioning it in the pulmonary artery. Chest X-ray in the immediate postoperative period showed the presence of a possible knot adjacent to the tip of the sheath in the internal jugular vein [Figure 1].

Because of the patient’s hemodynamic instability in the immediate postoperative period, catheter removal was postponed until the seventh day after surgery. An evaluation of the endovascular surgery was requested for its removal. Initially, the surgical team hypothesized that it was just doubled over.

The patient was then referred to the hemodynamics room, where, through fluoroscopy, an attempt to unfold the PAC was made using a guidewire. Without success, the possibility of a true knot was again raised. Thus, the surgical team decided to remove the PAC through the femoral vein. To do so, the PAC was introduced up to the topography of the left femoral vein guided by fluoroscopy. After femoral vein dissection, the PAC was pulled until the knot was out, and the PAC was cut in a region adjacent to the node [Figures 2 and 3]. The remaining part of the catheter was removed superiorly through the right internal jugular vein. The procedure was performed under local anesthesia and sedation, without any complications. On the tenth postoperative day, the patient was discharged from the intensive care unit.

**Discussion**

The most common complications of PAC are related to venous access puncture, such as accidental arterial puncture, hematoma, pneumothorax/hemothorax, bleeding, and more rarely, nerve damage, pseudoaneurysm formation, and air embolism.[1,3,4] Regarding the complications related to catheterization, arrhythmias stand out as the most common complication; however, less than 1% of patients evolving with arrhythmia require treatment.[1,3,4] Exceptionally, during PAC insertion, pulmonary artery perforation, intravascular knot, and intertwining with other vascular structures may occur.[1,3,4] Besides complications related to the permanence of the catheter (e.g., infection, thrombosis, valve injury, pulmonary infarction, and thrombocytopenia due to the heparin coating of the catheters), the misinterpretation of the data acquired through the PAC may lead to inappropriate management measures during the intraoperative or postoperative period.[1,3,4]

The incidence of knots in the PAC is estimated between 0.03% and 1%.[1,5] Just over 100 cases have been reported in the literature since the first report in 1954 by Johansson et al.[4] Moreover, it is estimated that PAC accounts for two-thirds of all intravascular catheter nodes.[4] This is due to its length and flexibility, which facilitate the occurrence of loops and
folds, especially when more than 50 cm of the catheter is inserted through the jugular or subclavian vein or more than 70 cm through the femoral vein.\textsuperscript{[1,4]} Moreover, it is assumed that the cardiac chambers’ turbulent flow and the fact that the catheter is usually inserted without direct visualization are other factors that predispose knot generation.\textsuperscript{[6]}

The knot formation is a technical complication that might be avoided if recommended procedures for its insertion are met.\textsuperscript{[1]}

In addition to controlling the length of the inserted catheter, as mentioned above, the PAC should not be inserted more than 15–20 cm after obtaining the right ventricular curve.\textsuperscript{[2]}

If wedge pressure is not achieved, the catheter should be carefully withdrawn to the 30-cm mark and then reinserted.\textsuperscript{[3]}

Instilling cold saline into it before insertion can help make it more rigid.\textsuperscript{[2]}

Partially inflating the balloon in the vena cava and fully inflating it after it reaches the right ventricle may facilitate the progression of the catheter tip to the pulmonary artery.\textsuperscript{[2]}

Using a PAC larger than 7 Fr and guiding its insertion through fluoroscopy or transesophageal echocardiography can also reduce the chance of knot formation.\textsuperscript{[2]}

Difficulties in mobilizing, inflating the catheter balloon, or obtaining the pulmonary pressure curve may be the first signs of an intravascular node formation.\textsuperscript{[2]}

At this point, it is recommended to interrupt blind maneuvers to avoid intracardiac structures injury, proceeding as soon as possible with a chest X-ray for the diagnosis of the case.\textsuperscript{[2,3]}

Interventional radiology is recommended as the first-line treatment for PAC’s knot removal.\textsuperscript{[4]}

Should it fail, surgical intervention might be considered.\textsuperscript{[4]}

Less invasive alternatives to the pulmonary artery catheter have been developed over time, such as bedside echocardiography, arterial waveform analysis, and transpulmonary thermodilution.\textsuperscript{[1]}

The medical team should weigh the risk and benefit of using the PAC and other hemodynamic monitoring methods available at each service. In addition, it is important to assess the patient’s clinical conditions, the benefits, and possible complications of each proposed procedure.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate guardian consent forms. In the form, the guardians have given their consent the patient images and other clinical information to be reported in the journal. The guardians understand that patient name and initial will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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