Editors' Choice

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Prevention and treatment of dilator injuries during central venous catheter placement

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CME Activity

Purpose or Statement of Need The purpose of this journal-based CME activity is to enhance the vascular specialist's ability to diagnose and care for patients with the entire spectrum of circulatory disease through a comprehensive review of contemporary vascular surgical and endovascular literature.

Learning Objectives

- Use the appropriate approach when inserting a central venous sheath
- Know the signs of central venous injury
- Be able to correct a central venous insertion complication

Target Audience This activity is designed for vascular surgeons and individuals in related specialties.

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ABSTRACT

Backround: Misuse of vascular dilators during the placement of central venous catheters has been infrequently reported and can lead to devastating intrathoracic hemorrhage and death. These injuries should be preventable in most cases. If a major intrathoracic vascular injury is recognized intraoperatively, less invasive treatment options are available to minimize the consequences.

Methods: The records of 20 patients who suffered 21 major vascular injuries during insertion of central venous catheters, ports, or dialysis catheters and resulted in malpractice claims over the course of 8 years were analyzed to determine the mechanism of injury, the timing of diagnosis, and how these injuries were treated. How the injury could have been prevented, why earlier diagnosis was not made, and what treatment options were possible were also examined.

Results: Twelve women and eight men were documented to have sustained intrathoracic major venous injuries during catheter insertions. There were five injuries to the superior vena cava, six to the right innominate vein, and 10 to the left innominate vein. All procedures were done using fluoroscopic guidance, and resistance to passage of the dilators was documented in eight cases. In most cases, the operator reported inserting the dilators to their maximum length. In four cases, the catheter could be seen intraoperatively in the thoracic cavity. Bleeding was diagnosed in the operating room in 11 cases, in the postanesthesia care unit in seven cases, and on postoperative days 2 and 5 after misplaced catheters were removed. Ten patients underwent thoracotomies and one patient each underwent thoracoscopy and placement of a covered stent in an attempt to stop the hemorrhage. Eight patients died before the diagnosis was made. Seventeen patients died.

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Conclusions: In spite of U.S. Food and Drug Administration warnings, dilators are still inserted too far in patients, resulting in devastating hemorrhage. These complications are preventable if proper technique is used. When a catheter is noted to be misplaced, it must not be removed before either a covered stent or thoracoscopy is available; otherwise, uncontrolled hemorrhage into the chest may occur. If a patient becomes unstable in the operating room or immediate postoperative period injury to a major vein must be considered and corrected quickly. (J Vasc Surg: Venous and Lym Dis 2019;7:789-92.)

Keywords: Dilators; Intrathoracic hemorrhage; Catheter

Accessing central veins is a common procedure that is performed in many clinical settings. Complications are not infrequent events.[1,2] Local complications have been reduced by the utilization of ultrasound guidance[3]; however, this practice does not prevent injuries to the deep, intrathoracic veins.

Major venous injuries that occur within the thorax secondary to misuse of the dilator have been reported. The majority of these reports have been anecdotal case reports.[4,5] There is very little evidence to suggest that a flexible, spring-loaded guidewire could perforate a major vein.[3] The dilator is the only instrument that has the stiffness and point that is capable of perforating a central vein.[3,6] This can happen in one of three ways. The wire may be pulled back inside the dilator, offering the tip of the dilator no protection; a short segment of wire may protrude from the end of the dilator, offering minimal protection from perforation; or the dilator may push the wire, creating a "bowstring effect" and thus a large tear in the vein.[1] Preventive measures have been proposed. These include not advancing the device against any resistance, not placing the dilator in more than is necessary to get the sheath into the vein that is accessed, and moving the wire back and forth to ensure free movement while advancing the dilator/sheath.[3]

Perforation of a central vein may not be recognized at the time of injury. This may be because the operator does not appreciate the possibility of this happening or because the catheter is running medially in the right chest cavity and appears to be in the superior vena cava (SVC) on the anteroposterior image.

Procedural-related complications are becoming known as "never events" (implying that they should never happen) that have not only clinical and medico-legal implications, but, potential reimbursement issues.[8] Payers are establishing reporting requirements that will no longer reimburse for any of the costs that arise from a procedure-related complication. It is essential that physicians use proper technique to reduce these devastating complications and that industry modify and better label the devices to improve outcomes.

METHODS

The medical records, imaging, and deposition transcripts of 20 completed medico-legal cases that were the direct result of an injury suffered during placement of a device over an 8-year period were reviewed. The author served as an expert on all of these cases between 2008 and 2014. The operative reports and surgeons' depositions were reviewed to determine if any resistance was noted during the placement of the device, how far the dilators were inserted, and at what times fluoroscopy was used. These were also reviewed to determine exactly when the injury was suspected and diagnosed and what steps were taken when the injury was recognized. The operative log and billing records were reviewed to determine if any nonstandard or stiffer wires were used during the procedure. The medical records and X-rays were examined in a similar fashion if the injury was diagnosed after the operation was complete. The outcome of the case was noted. The records and X-rays were then reviewed to determine how the injury could have been prevented and whether an earlier diagnosis could have been made.

Twenty patients sustained 21 injuries during 20 central venous access procedures. There were 12 women and eight men, aged 32 to 80 years old. Fourteen patients were having dialysis catheters placed and six patients were having access established for chemotherapy or nutritional support. There were five injuries to the SVC, six to the right innominate vein, and 10 to the left innominate vein. These were either confirmed by imaging with contrast or on postmortem examinations. One patient had injuries to both the left innominate vein and the SVC during one procedure. No nonstandard or extra-stiff wires were used in any of the cases. Ten surgeons documented or recalled using fluoroscopy every time the dilator was advanced, whereas 10 did not. Those 10 stated that the catheter would "follow the wire" and could not perforate a vein. Video images were saved in five cases. In three of these cases, the wire had pulled back and only had a short amount of wire protruding from the end of the dilator. Two had no visible wire protruding past the tip of the dilator.

Eight surgeons recalled feeling resistance as they advanced the dilator and sheath during their depositions. All of these operators stated that they thought that the resistance was created by the dilator sheath passing through the skin. None of the surgeons noted an increase in resistance when the major vein was perforated.

Seventeen of the dilators were placed to their maximum distance or far enough to perforate the central vein. This was determined through deposition

testimony of the operator or by visualization on preserved fluoroscopic images. In three cases, the length of dilator inserted was not recorded. None of the dilators had distance markers on them and, according to the operators, all of the dilators were of sufficient length to reach the heart. All of the operators stated that the only way to place the catheter was by advancing the dilator sheath fully into the vein. There were no arterial injuries identified.

Four of the major venous injuries were diagnosed intraoperatively when the catheter was noted to be misplaced in the chest cavity and causing some bleeding. One was treated successfully with a covered stent and one was treated with thoracoscopic repair. Two exsanguinated after the catheter was removed and bleeding could not be controlled when thoracotomies were performed.

Eleven patients were diagnosed with major pleural bleeding in the operating room. Chest tubes were originally placed in seven patients. Seven underwent thoracotomy; one of these patients survived. One each had a covered stent and thoracoscopic repair and survived. Seven patients became unstable in the postanesthesia care unit. All seven had chest X-rays that confirmed intrapleural hemorrhage. Five had chest tubes placed. All died before they could have their bleeding controlled. One patient was diagnosed with a dialysis catheter in the thoracic cavity on postoperative day 2 and one on postoperative 5 when dialysis could not be performed. Both of these catheters appeared to be in the appropriate location on the posteroanterior X-ray because they ran in the medial posterior right chest cavity and paralleled the SVC. Repeat imaging showed that they were misplaced. Both patients had their catheters removed while a new dialysis catheter was being placed. One had successful control of the hemorrhage during a thoracotomy. The other catheter was removed in a procedure room and exsanguinated before being moved to the operating room.

During the procedure, some increased opacification of the ipsilateral chest was misidentified as being caused by the drapes or patient positioning in four cases. This increased density was only correctly diagnosed as being caused by blood after the patient became markedly hypotensive and unstable in the postanesthesia care unit. None of these patients survived. Nineteen of the 20 cases were either settled before trial or resulted in a plaintiff's verdict.

DISCUSSION

Major venous injuries during placement of central venous devices cause significant morbidity and have a high mortality rate, especially if the injury is not rapidly diagnosed and treated. The medico-legal liability is significant because these injuries are believed to be avoidable and preventable. Because procedural-related complications are more frequently being considered as "never events," there may be a financial burden imposed on the operator and institution because reimbursement for the additional care needed to treat the complication will be denied.[1]

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective case reviews
- **Key Findings:** Major intrathoracic venous injuries from misuse of dilators during central venous access in 20 patients resulted in 17 deaths (85%). The most common injury was to the left innominate vein (48%).
- **Take Home Message:** Major vascular injuries with dilators during central venous access can be prevented with proper attention to technique. Mortality can be reduced with early recognition and treatment with minimally invasive techniques.

Prevention of these injuries is paramount. Wires and dilators must never be advanced against any resistance. Dilators should only be advanced far enough to enter the vein that is accessed and no further. The catheter can then be placed through the sheath into the vein. Once a catheter is in the central vein, it will usually follow the flow and move to the correct position. If the catheter cannot be advanced or does not go to the correct location, a glide wire can be inserted through the catheter and manipulated into the correct location. Fluoroscopy must be used whenever the dilator is advanced to be sure it is not affecting the wall of the vein. It is recommended that a small puff of contrast be placed through the catheter at the end of the procedure to be 100% sure that the catheter is intraluminal. Venous return can sometimes be misleading if intrathoracic blood is aspirated through the catheter.

The operator must have a high index of suspicion that a major vein perforation has occurred if any hemodynamic instability occurs, there is poor venous return through the catheter, any resistance was encountered during placement, or if the catheter follows a different course than expected. There should be a low threshold to inject contrast into the catheter if misplacement is suspected or intravenously if a perforation is being considered. If there is any doubt, contrast should be injected through the catheter to be positive that it is intravascular. If there is a central venous perforation recognized, do not simply remove the dilator or catheter because this may result in catastrophic hemorrhage. There are endoluminal[6] and video-assisted limited thoracotomy techniques[7] available to limit the amount of bleeding and the need for a thoracotomy. If the catheter is misplaced, it must not be removed until either a stent graft is available and in position to be placed[6] or a thoracoscope can be readied to repair the hole before the catheter is pulled.[8]

Industry has known that dilators have been perforating major veins for more than 2 decades,[5] yet no improvements have been made. Although there are instructions and warnings in every central venous catheter kit about the possibility of cardiac tamponade occurring from misplaced catheters,[9,10] there are no instructions about precautions pertaining to dilator insertion.[5] Videos that demonstrate the proper use of dilators should be included on industry websites. There is no need for dilators of excessive length. Shorter dilators should be provided in the insertion kits so that they only are used to dilate the skin, subcutaneous tissue, muscle, and entry in to the vein. Markers should be on the dilators just as they are present on central venous catheters so that the depth of insertion can be known and documented.

CONCLUSIONS

In summary, major venous perforations from vessel dilators are preventable with proper technique. A high index of suspicion about the possibility of perforation is essential if the morbidity and mortality from these injuries are to be eliminated. If a catheter is misplaced, it must not be removed until the operator is ready to take care of the hole in the vein before exsanguinations occurs. Industry should work with the U.S. Food and Drug Administration to make changes in the design of the dilators and highlight the warnings in the package insert to help prevent this complication from happening.

AUTHOR CONTRIBUTIONS

Conception and design: PC
Analysis and interpretation: PC
Data collection: PC
Writing the article: PC
Critical revision of the article: PC
Final approval of the article: PC
Statistical analysis: PC
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