Innominate vein repair after iatrogenic perforation with central venous catheter via mini-sternotomy—Case report

Juan A. Siordia *, Georganne R. Ayers, Amanda Garlish, Sreekumar Subramanian

Department of Surgery, University of Arizona Medical Center, University of Arizona, 1501 N Campbell Ave., Tucson, AZ 85719, United States

ARTICLE INFO

1. Introduction

Minimally invasive techniques are being utilized frequently during this age due to patient demand and promising outcomes. Mini-sternotomy approaches are one example of minimizing surgical trauma to the patient while performing the primary repair operation. Mini-sternotomy approaches have already been analyzed and shown feasible for certain cardiovascular surgical procedures, including aortic valve replacement and ascending aorta repair [1,2]. However, belief drives the concept that the approach can be performed in a multitude of thoracic procedures. The following case report pertains to a mini-sternotomy approach for innominate vein repair after iatrogenic perforation from instillation of a central venous line catheter via the left subclavian vein.

Central venous catheters are implemented for a wide array of circumstances both short and long term. The use of these catheters albeit beneficial are not without risk. One such complication is the iatrogenic perforation of the blood vessel during the course of cannulation [3,4]. Examination of the anatomy has determined that the left sided approach for hemodialysis cannulation presents a unique complication imposed by the angle between the subclavian and innominate vein [3]. We present a case of a tunneled hemodialysis catheter causing iatrogenic perforation of the innominate vein.

2. Case report

A 75 year old female patient with hypertension, diabetes mellitus type two and end stage renal failure, coronary artery disease. The patient suffered from iatrogenic innominate vein perforation after placement of a tunneled hemodialysis catheter through the left subclavian approach. Computed tomography of the chest confirmed perforation of the innominate vein (Fig. 1). A transesophageal echocardiogram confirmed pericardial effusion. Vascular surgery performed contrast angiography via the subclavian hemodialysis catheter confirming extravascular fluid trapping suggesting perforation (Fig. 2). A partial upper sternotomy was performed into the right fourth intercostal space and a rib spreading retractor was placed; opening the pericardium and pericardial retraction sutures were placed. A single 4-0 Prolene pledgeted suture was used to circumscribe the perforation site; the catheter was withdrawn due to the inability of its advancement based on...
Innominate vein and SVC, its distal tip at the level of the inferior SVC. Contrast injection usage, and faster return to normal activity for patients [1].

A central venous catheter is seen coursing along the expected location of the left innominate vein anteriorly and then laterally to the superior vena cava. There is evidence of pneumomediastinum anteriorly. No evidence of significant mediastinal hematoma or hemopericardium. No pneumothorax.

For aortic valve replacement, Furukawa et al. demonstrate that 18 of 34 conversion to full median sternotomy are due to poor exposure; a feature that is vital in all surgical procedures for optimal results [5]. Tabata et al. report the incidence rate of conversion to be 2.6%, with the most common reasons for conversion including bleeding, ventricular dysfunction, and poor exposure; the mortality rate of converted cases increases to 33.3% [6].

Venous catheter insertions are performed by medical staff that have had adequate amount of experience and training. When inserting the venous catheter, the Seldinger technique is typically employed, utilizing guide wires and dilation catheters in order to carefully guide the catheter to the central venous circulation. While landmarks can be used for guidance and orientation, ultrasounds have also been used for certainty of insertion. Results and outcomes of central venous catheter are dependent on the site of insertion. Central venous catheter access can cause iatrogenic injury toward surrounding structures if not performed properly or accurately. Complications that may arise with insertion include hemothorax, pneumothorax, chylothorax, cardiac tamponade, infections, nerve injuries, and vessel perforation [4,7,8]. A systematic review containing 17 trials of data on 2085 jugular and 2428 subclavian catheters describes the results of the two entrances. Jugular venous catheters demonstrated higher outcomes of arterial punctures than the subclavian approach (3% vs. 0.5%, RR 4.70 [95% CI, 2.05–10.77]). However, malposition was significantly less with the jugular access compared to the subclavian approach (5.3% vs. 9.3% RR 0.66 [0.44–0.99]) [9]. In terms of left vs. right insertions, however, the left produces more complications due to the angulations of vessels [3,4].

When inserting the catheter, one vital step includes checking whether the catheter is inserted in the proper location and vessel. Aspiration of fluid is crucial in order to determine whether the catheter has been inserted in the vessel [3]. Bright blood suggests oxygenated blood, which signifies an arterial vessel in the systemic circulation. Darker blood suggests venous blood, which suggests the catheter is placed within a systemic venous vessel. However, if no blood is aspirated, it may signify malposition of catheter insertion. Based on the orientation and knowledge of anatomy, it could signify iatrogenic trauma to surrounding structures, including the pleura, pericardium, or central vessels. Instead of withdrawing the catheter to re-attempt insertion, it is suggested to insert contrast dye into the location [3,4]. This will not only provide a tamponade effect, if a vessel was perforated, but it also reveals the location of the catheter tip when employing imaging modalities. Computed tomography provides the most accurate location of the catheter; radiographs may prove inaccurate or lacking detail [3,4].

If hemodynamically stable, the patient should undergo imaging to determine the location of the catheter. Note that the central venous line should remain within the attempted location. Surgery is then typically required to remove the catheter without complications while repairing any perforations [3,7]. Based on the location of the catheter, the approach may require a sternotomy approach if it involves the innominate vein or other mediastinal vessels, or a thoracotomy if the vena cava is affected.

New less invasive approaches have been demonstrated to fix iatrogenic damage with central venous catheters. Azzuzadah et al. demonstrate an endovascular approach to repair perforations of the vena cava [8]. However, complications that have been noted to arise with the use of stent placement include superior vena cava syndrome – iatrogenic occlusion. Kuznecj et al. explain a video thoracoscopic approach for fixing perforation of the vena cava [7]. This approach is slightly more invasive than the endovascular approach, the ensures no development of superior vena cava syndrome, no necessity of foreign stent material, and complete resolution of possible complications that may arise from the iatrogenic trauma. Other approaches have been described that include

**Discussion**

The mini-sternotomy approach has demonstrated favorable outcomes compared to the traditional median sternotomy incision. For aortic valve replacement, Furukawa et al. [1] demonstrate that the rate of stroke, perioperative myocardial infarction, low-output syndrome, new onset dialysis, and re-exploration for bleeding were similar between the two approaches. However, they add that the mini-sternotomy provides less post-operative pain, less pain medication usage, and faster return to normal activity for patients [1]. The primary limiting factor about the mini-sternotomy approach is the reduced exposure of the operating field. Johnston et al. report the incidence rate of conversion to full median sternotomy are due to poor exposure; a feature that is vital in all surgical procedures for optimal results [5]. Tabata et al. report the incidence rate of conversion to be 2.6%, with the most common reasons for conversion including bleeding, ventricular dysfunction, and poor exposure; the mortality rate of converted cases increases to 33.3% [6].

Venous catheter insertions are performed by medical staff that have had adequate amount of experience and training. When inserting the venous catheter, the Seldinger technique is typically employed, utilizing guide wires and dilation catheters in order to carefully guide the catheter to the central venous circulation. While landmarks can be used for guidance and orientation, ultrasounds have also been used for certainty of insertion. Results and outcomes of central venous catheter are dependent on the site of insertion. Central venous catheter access can cause iatrogenic injury toward surrounding structures if not performed properly or accurately. Complications that may arise with insertion include hemothorax, pneumothorax, chylothorax, cardiac tamponade, infections, nerve injuries, and vessel perforation [4,7,8]. A systematic review containing 17 trials of data on 2085 jugular and 2428 subclavian catheters describes the results of the two entrances. Jugular venous catheters demonstrated higher outcomes of arterial punctures than the subclavian approach (3% vs. 0.5%, RR 4.70 [95% CI, 2.05–10.77]). However, malposition was significantly less with the jugular access compared to the subclavian approach (5.3% vs. 9.3% RR 0.66 [0.44–0.99]) [9]. In terms of left vs. right insertions, however, the left produces more complications due to the angulations of vessels [3,4].

When inserting the catheter, one vital step includes checking whether the catheter is inserted in the proper location and vessel. Aspiration of fluid is crucial in order to determine whether the catheter has been inserted in the vessel [3]. Bright blood suggests oxygenated blood, which signifies an arterial vessel in the systemic circulation. Darker blood suggests venous blood, which suggests the catheter is placed within a systemic venous vessel. However, if no blood is aspirated, it may signify malposition of catheter insertion. Based on the orientation and knowledge of anatomy, it could signify iatrogenic trauma to surrounding structures, including the pleura, pericardium, or central vessels. Instead of withdrawing the catheter to re-attempt insertion, it is suggested to insert contrast dye into the location [3,4]. This will not only provide a tamponade effect, if a vessel was perforated, but it also reveals the location of the catheter tip when employing imaging modalities. Computed tomography provides the most accurate location of the catheter; radiographs may prove inaccurate or lacking detail [3,4].

If hemodynamically stable, the patient should undergo imaging to determine the location of the catheter. Note that the central venous line should remain within the attempted location. Surgery is then typically required to remove the catheter without complications while repairing any perforations [3,7]. Based on the location of the catheter, the approach may require a sternotomy approach if it involves the innominate vein or other mediastinal vessels, or a thoracotomy if the vena cava is affected.

New less invasive approaches have been demonstrated to fix iatrogenic damage with central venous catheters. Azzuzadah et al. demonstrate an endovascular approach to repair perforations of the vena cava [8]. However, complications that have been noted to arise with the use of stent placement include superior vena cava syndrome – iatrogenic occlusion. Kuznecj et al. explain a video thoracoscopic approach for fixing perforation of the vena cava [7]. This approach is slightly more invasive than the endovascular approach, the ensures no development of superior vena cava syndrome, no necessity of foreign stent material, and complete resolution of possible complications that may arise from the iatrogenic trauma. Other approaches have been described that include...
minimal incision, but with the removal of the first anterior rib and splitting of the pectoralis major fibers to reveal the subclavian vein [10,11]. The case presented in this report suggests a new approach to replace the traditional complete median sternotomy in attempts to repair the innominate vein. The mini-sternotomy approach provides sufficient visualization of the vessel and surrounding structures with minimal post-operative complications and healing time.

Conflict of interest

None.

Funding

None.

Ethical approval

Approval has been given by the ethics committee and the patient involved.

Consent

Consent has been acquired by the patient.

Author contribution

Juan Arturo Siordia – primary author.
Georganne Ayers – secondary author.
Amanda Garlish – abstract author.
Sreekumar Subramanian – primary physician.

Guarantor

Juan Arturo Siordia is the guarantor.

References

[1] N. Furukawa, O. Kuss, A. Aboud, M. Schonbrodt, A. Renner, M. Hakim, et al., Ministernotomy versus conventional sternotomy for aortic valve replacement: matched propensity score analysis of 808 patients, Eur. J. Cardiothorac. Surg. 46 (2) (2014) 221–227.
[2] M. Vigano, M. Rinaldi, A.M. D’Armini, M. Boffini, G.F. Zattera, A. Alloni, et al., Ascending aortic aneurysms treated by cuneiform resection and end-to-end anastomosis through a ministernotomy, Ann. Thorac. Surg. 74 (5) (2002) 1789–1791.
[3] U. Pua, Central vein perforation during tunneled dialysis catheter insertion: principles of acute management, Hemodial. Int. 18 (4) (2014) 838–841.
[4] M.D. Tilak, S.M. Proctor, J.F. Donovan, J.C.K. Fitch, Extravascular placement of a central venous catheter in the mediastinum, J. Cardiothorac. Vasc. Anesth. 18 (1) (2004) 75–77.
[5] D.R. Johnston, F.A. Atik, J. Rajeswaran, E.H. Blackstone, E.R. Nowicki, J.F. Sabik, et al., Outcomes of less invasive J-incision approach to aortic valve surgery, J. Thorac. Cardiovasc. Surg. 144 (2012) 852–858.
[6] M. Tabata, R. Umakanthan, Z. Khalpey, G.S. Couper, S.F. Aranki, L.H. Cohn, et al., Full sternotomy conversion following minimal access cardiac surgery: reasons and rationales during a 9.5 year experience, J. Thorac. Cardiovasc. Surg. 134 (2007) 165–169.
[7] S. Kuzniec, S.R.B. Natal, E. Werebe, N. Wolosker, Videotorhorascopscopic-guided management of a central vein perforation during hemodialysis catheter placement, J. Vasc. Surg. 52 (2010) 1354–1356.
[8] A. Azizzadeh, M.T. Pham, A.L. Estrera, S.M. Coogan, H.J. Safi, Endovascular repair of an iatrogenic superior vena caval injury: a case report, J. Vasc. Surg. 46 (2007) 569–571.
[9] S. Ruesch, B. Walder, M.R. Tramer, Complications of central venous catheters: internal jugular versus subclavian access—a systematic review, Crit. Care Med. 30 (2) (2002) 454–460.
[10] J.E. Molina, A new surgical approach to the innominate and subclavian vein, J. Vasc. Surg. 27 (3) (1998) 576–581.
[11] A.W. Knott, S.D. Cassivi, P. Gloviczki, Open central venous reconstruction: technique, advantages, and pitfalls of partial sternotomy with infraclavicular resection of the first rib, Perspect. Vasc. Surg. Endovasc. Ther. 20 (2) (2008) 214–219.

Open Access

This article is published Open Access at sciencedirect.com. It is distributed under the IJSCR Supplemental terms and conditions, which permits unrestricted non commercial use, distribution, and reproduction in any medium, provided the original authors and source are credited.