Bilateral Chest Injury after Landmark-Guided Difficult Central Venous Cannulation-a Case Report

Nora Mihalek[1,2], Katarina Krstic[1], Sanja Starcevic[1,2], Dragana Radovanovic[1,2], Gabor Erdoes[3]

[1] *Oncology Institute of Vojvodina, Department of Anaesthesiology and Intensive Care, Sremska Kamenica, Serbia*

[2] *Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia*

[3] *Inselspital, University Hospital Bern, University of Bern, Department of Anaesthesiology and Pain Medicine, Bern, Switzerland*

Abstract

Central venous catheter placement is a high-risk procedure in anesthesia practice. We report a case of bilateral chest injury after difficult central venous catheter placement according to the landmark technique. Thirty hours after central venous catheter placement, the patient developed a right-sided hydrothorax (secondary to malposition of the central venous catheter) and a left-sided pneumothorax (secondary to multiple attempts at central venous catheter insertion). The patient was intubated and bilateral chest drainage was performed. This report underlines the importance of avoiding bilateral central venous puncture and highlights the importance of proper diagnostics to detect post-intervention complications.

Keywords: central venous catheter, central venous puncture, chest radiograph, complications, hydrothorax, landmark technique, pneumothorax

Background

Central venous catheter (CVC) placement represents one of the most frequently performed interventions, not only in the intensive care unit (ICU), but also in the perioperative setting. With a CVC, it is possible to continuously monitor hemodynamic parameters, determine patient fluid requirements, administer infusions, drugs (e.g., vasopressors, sedatives), blood products, and perform parenteral nutrition.[1] It is well known that in addition to the numerous benefits, this procedure is also associated with serious, and in many cases, life-threatening complications. Common early complications of central venous catheterization are pneumothorax, hemothorax, air embolism, catheter malposition, and vascular injury. Late complications include catheter-related bloodstream infection, thrombosis, catheter rupture with possible extravasation or migration.[2] The incidence of the above complications may be as high as 18% if the procedure is performed without the use of ultrasound guidance.[3] However, the complication rate is significantly associated with several factors, primarily the working environment (e.g., partially or fully equipped) and the experience of the anesthesiologists.

Correspondence to: Nora Mihalek, MD, E-mail: noramihalek@gmail.com

Received May 24, 2023, Revised November 15, 2023, Accepted November 15, 2023

The simultaneous occurrence of two complications in the same patient is unusual, and such cases require special attention and additional investigations. In this case report, we presented a patient who was at risk of life-threatening complications due to the simultaneous manifestation of two CVC placement-related complications. Thirty hours after CVC placement into the right subclavian vein, the patient developed a hydrothorax on the right side-as a consequence of CVC malposition, and a pneumothorax on the left side-as a result of multiple CVC insertion attempts into the left jugular vein.

Case presentation

A 76-year-old female patient was admitted to the surgical department one day before planned abdominal surgery. The preoperative physical examination and medical record review revealed important co-morbidities of the patient: hypertension, allergic bronchitis and myocardial infarction 14 years ago with subsequent coronary artery bypass grafting (single vessel disease). Because of these circumstances, the perioperative risk was considered moderately increased. The patient regularly consumed bisoprolol, acetylsalicylic acid, captopril, atorvastatin, scopolamine and ibuprofen. Segmentectomy SV and SVI of the liver was performed due to pathohistologically proven hepatocellular carcinoma. The operation proceeded without complications and without significant bleeding. Balanced general anesthesia with propofol induction (1.5-2.5 mg/kg i.v.) and sevoflurane maintenance (1.2-1.4% end-tidal or 1-1.2 MAC) was administered. The nondepolarizing muscle relaxant rocuronium bromide was administered at an induction dose of 0.6 mg/kg i.v. and boluses of 0.1-0.3 mg/kg i.v. as clinically required (total dose of 80 mg i.v.). Analgesia was provided intraoperatively with boluses of fentanyl (50-100 mcg i.v., total dose 350 mcg i.v.) and postoperatively with boluses of morphine hydrochloride (2.5-5 mg i.v.) and ketorolac (30 mg i.v.). An endotracheal tube was used for airway management, and pressure-regulated volume-controlled ventilation was provided. The total operation time was 2 hours and 40 minutes, and the anesthesia time was 3 hours and 45 minutes. The patient was intraoperatively hemodynamically stable, with adequate respiratory parameters, gas exchange, and satisfactory diuresis. Reversal of anesthesia and extubation were without complications.

Prior to the surgical procedure, a CVC placement using the Seldinger technique was planned. Initially, an attempt was made using surface landmark to insert the CVC into the right jugular vein, but after an unsuccessful attempt without arterial puncture, the left jugular vein followed by the right subclavian vein were cannulated. At this time, another experienced anesthesiologist was asked for assistance, and after several attempts, the CVC was successfully placed in the right subclavian vein. The position of the catheter was checked by aspirating venous blood from all catheter lumina at the depth of 14 cm, and after completion of the CVC placement, a crystalloid infusion was administered through the medial CVC lumen. After the surgical procedure, the patient was transferred to the ICU, where a chest radiograph was taken two hours after admission to verify the position of the CVC. The radiograph proved

Table 1 Arterial blood gas analyses in different time points

	1st postop. day 17:06	1st postop. day 19:40	1st postop. day 22:52	2nd postop. day 04:58
pH	7.10	7.32	7.34	7.35
pCO_2 [kPa]	10.3	5.9	5.9	6.0
pO_2 [kPa]	11.6	10.6	13.1	12.4
sO_2 [%]	95.7	97.4	99.2	98.8

the correct position of the catheter tip - in the superior vena cava, with no signs of pneumothorax. For the rest of the day, postoperative recovery was adequate - the patient had no subjective complaints, hemodynamic variables were stable, respiration was adequate, diuresis was adequate, and there was no significant amount of drainage from the abdominal drains.

On the first postoperative day, the recovery was satisfactory, so oral fluid administration was started and chronic cardiac medications were administered. Around 12 noon, failure to aspirate blood from CVC lumen was reported, but crystalloid infusion fluid was done through the catheter without difficulty. The position of the CVC was not changed (determined by depth mark), but the administration of fluids and medications was stopped. Around 4 pm, the patient suddenly became agitated, hemodynamically unstable (BP 220/100 mmHg, HR 140 beats/min), and tachypneic. Auscultation findings indicated spasm of the distal airways, and electrocardiography showed sinus rhythm with HR of 150 beats/min. The following therapy was ordered: metoprolol 5 mg iv + 2.5 mg iv, methylprednisolone 40 mg iv + 40 mv iv, aminophylline 240 mg iv and furosemide 20 mg iv. Arterial blood gas analyses showed severe respiratory acidosis (pH = 7.10) with CO_2 retention (pCO_2 = 10.3 kPa/77 mmHg). A chest radiograph was performed which showed a hydrothorax on the right side completely covering the right lung and displacing the mediastinum to the left, and a pneumothorax on the left side was described (Figure 1). Due to severe respiratory insufficiency, respiratory arrest occurred at 6pm, when the patient was intubated, the thoracic surgeon on duty was called urgently and bilateral chest drainage was performed. The right chest drain had an initial volume of 2000 mL of serous drainage (equivalent to the amount of crystalloid infusion the patient had received via the CVC the day of the operation and the first postoperative day), but the left chest drain had no drainage or air. Both drains were set to active suction. A portable chest radiograph was obtained, which showed the correct position of the chest drains and a marked reduction of right lung shadowing. The radiological findings on the left side remained unchanged. Two hours later, gas exchange was adequate and the patient could be extubated. No more drainage was present at the right chest drain, but some gas bubbles appeared at the left chest drain.

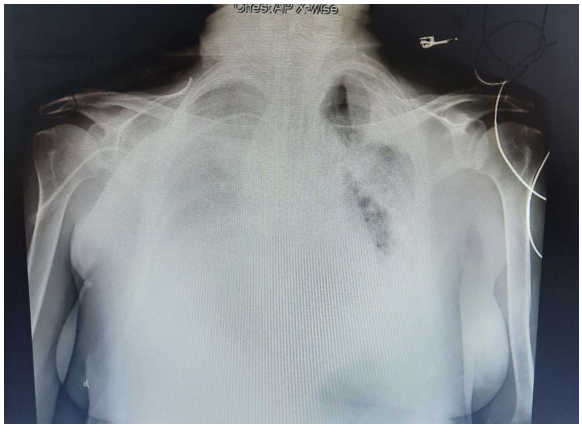


Figure 1 Chest radiograph after symptom onset The chest radiograph shows a hydrothorax covering the right lung and displacing the mediastinum to the left, and a pneumothorax on the left side.

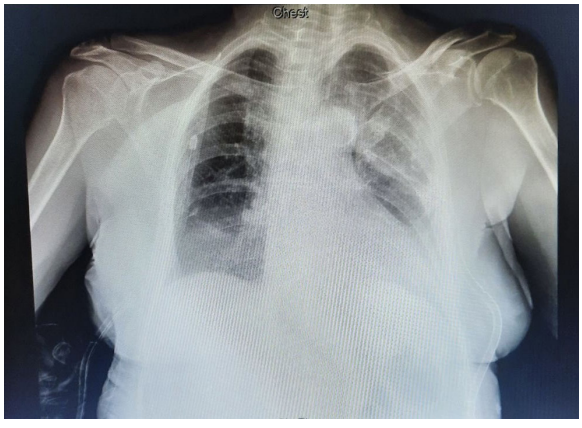


Figure 2 Chest radiograph on the second postoperative day The chest radiograph shows the correct position of the chest drains and marked improvement of the pulmonary finding (reduction of the right lung shadowing).

On the second postoperative day, the control chest radiograph showed marked improvement (Figure 2). On the fourth postoperative day, the right chest tube was removed and the left chest tube was set to passive suction. On the fifth postoperative day, the left chest drain was clamped and removed shortly thereafter, and the patient was transferred to the surgical ward. During the remainder of her hospital stay, the patient's postoperative course and recovery were satisfactory, and she was discharged from the hospital on the eighth postoperative day after radiological confirmation of the appropriate pulmonary findings.

Discussion

The placement of a CVC is a procedure with a high risk for the development of numerous complications. The frequency and severity of complications depend on several factors, but the occurrence of multiple complications in the same patient is extremely rare. A study that investigated the complication rates of CVC insertion showed that there was no statistically significant difference in the incidence of early and late complications after CVC insertion between insertion into the jugular vein, subclavian vein, and femoral vein.[4] A review article analyzing the development of complications after placement of a CVC described a lower incidence of mechanical complications after placement of a CVC in the internal jugular vein than after placement in the subclavian vein, whereas infection-related complications occurred less frequently after placement in the subclavian vein.[5]

CVC malposition is a common phenomenon in anesthesia practice, and according to the results of a prospective clinical trial, radiologically proven malposition of the CVC tip is described in 3.3% of cases-as extrathoracic or ventricular position of the CVC tip.[6] This phenomenon occurs significantly more often (14%) when

the CVC is placed in the internal jugular vein compared to the subclavian vein.[5] According to the guideline of the American Society of Anesthesiologists (ASA) the radiological confirmation of the catheter position should be obtained in the early postoperative period, as soon as clinically appropriate, before use of the CVC.[7] In our patient, a control chest radiograph was obtained two hours after the surgical procedure to verify the position of the CVC and to exclude the possibility of iatrogenic pneumothorax as an expected complication. The radiographs performed proved the adequate position of the CVC tip, and there was no evidence of pneumothorax. It is likely that in this case, the control chest radiograph was performed too early in the postoperative period, when signs of a possible complication of CVC placement had not yet appeared. Evidence suggests that the location of the CVC was appropriate on the day of surgery and that the significant signs of pneumothorax did not appear until later in the postoperative period.

To date, there are no clear guidelines describing at what point clinicians should perform a control chest radiograph after CVC placement. However, in the case of our patient, we can assume that the appropriate time between the end of the surgical procedure and the control radiograph was longer than two hours. The first sign that indicated a possible CVC malposition was failure to aspirate blood from the catheter on the first postoperative day. Because crystalloid fluids flowed through the catheter without difficulty despite the impossible blood aspiration, the position of the catheter was assumed to be non-displaced. The decision not to remove the catheter was based on the demonstrated appropriate position of the catheter on the previous day. The reason why the first signs of the complications appeared late, on the first postoperative day is not fully understood. The patient received minimal amount of crystalloid infusions through the CVC in the operating room and most of the fluids were administered through peripheral veins on the day of the operation. The ample administration of infusions through the CVC was started late on the day of the intervention and continued on the first postoperative day. Therefore, it is supposed that the warning signs appeared late in the postoperative period, due to the postponed fluid administration through the catheter. However, the time point when the catheter malposition occurred and the reason why the radiologic signs of pneumothorax were not recognized, remain unknown. A study following 90 patients with severe chest trauma reports that in 35 cases chest radiography failed to detect pneumothorax.[8] Clinicians need to take into consideration that in many cases chest radiography is not sensitive enough. Our patient could be considered to be a high-risk patient for the development of serious complications, as multiple attempts of central venous cannulation were conducted. In those cases, it may be recommended to obtain other, more sensitive diagnostic procedures, such as CT scan.

Our patient did not demonstrate any clinical signs of the persisting pneumothorax in the early postoperative period; however, this undetected situation could lead to further complications during mechanical ventilation and general anesthesia (with nitrous-oxide).[8] Although peripheral intravenous access is more suitable for fluid administration, a central

venous access was used for fluid resuscitation in our patient in addition to its primary purpose. Cannulation of the peripheral veins in the upper extremities before surgery was difficult because of nonpalpable and nonvisible veins, so a peripheral 18-G venous catheter was placed. Cannulation of the external jugular vein was intended but could not be successfully performed because of the short neck anatomy and mild obesity. In the case of our patient, the orientation to the anatomical structures was extremely difficult due to short neck anatomy and moderate obesity. Therefore, the experienced anesthesiologists performed bilateral punctures, thus one important rule of CVC placement was crossed. Complications usually occur on the side where the CVC was placed, i.e., the side where the insertion was performed. Therefore, it is recommended to avoid bilateral cannulation attempts of the central vein if possible. In the case of bilateral lung injury, the compensatory mechanisms of the organism are limited, and in the case of an inadequate response by the medical staff, even a fatal outcome may occur.

According to the latest guidelines, it is recommended to routinely use an ultrasound imaging during CVC placement to decrease the complication rate and increase patient safety.[9] According to a recent study, the complication rate for subclavian vein insertion is significantly lower when the procedure is performed using ultrasound than in patients in whom CVC insertion is based on the landmark technique.[10] The results of a review article analyzing the efficacy of ultrasound-guided CVC placement in the internal jugular vein indicate that the use of a two-dimensional ultrasound during central vein puncture decreased the overall complication rate by 71% when the CVC was placed according to the anatomic landmarks.[11] In our case, the experienced anesthesiologists did not use an ultrasound because an ultrasound system was temporarily unavailable. Chest radiography has often been used to confirm the position of the CVC tip and to detect complications after the procedure, although this method appears to be suboptimal in detecting pneumothorax and CVC malposition. This strategy is relatively cost-effective but exposes patients to unnecessary radiation and may lead to delayed deployment of the CVC.[12] Zanobetti and coworkers reported high agreement between chest radiographs and ultrasonography in determining the location of the CVC. Mechanical complications were also detected by ultrasound and confirmed by chest radiographs. However, the time required for ultrasonography was much less than for chest radiography, so ultrasonography allowed earlier deployment of the CVC and immediate administration of medications, which is very important in critically ill patients.[13] According to a meta-analysis that included 25 studies, ultrasonography is an accurate and feasible diagnostic method for detecting CVC malposition and pneumothorax.[14]

Conclusion

We conclude that in our patient, the use of an ultrasound system during CVC placement would have been helpful and bilateral punctures could have been avoided. It is likely that the

control chest radiograph was performed too early in the postoperative period and, therefore, visualization of a developing pneumothorax was not possible. The inability to aspirate blood from the CVC on the first postoperative day was a warning sign of the impending complication, which led to a life-threatening condition in our patient. This case report indicates the suboptimal efficacy of chest radiography in detecting CVC malposition when chest radiography is performed immediately or in a short time interval after surgery. This evidence raises concerns about the high reliability of chest radiography. In addition, this report describes the possible occurrence of life-threatening complications after placement of a CVC, even 30 hours after central line insertion. We suggest – in line with current guidelines – that CVC placement should be performed with ultrasound-guidance. Furthermore, caution is advised in case of bilateral puncture. This should not be performed or only under utmost caution (with appropriate written documentation) – in awareness of possible complications such as pneumothorax, so that in case of suspicion, immediate appropriate diagnostic and therapeutic steps can be taken.

List of Abbreviations

CVC – central venous catheter
ICU – intensive care unit
BP – blood pressure
HR – heart rate
ASA – American Society of Anesthesiologists

Ethics approval and consent to participate

Written informed consent was obtained from the patient for participating in this study.

Authors' contributions

Authors NM and KK collected and analyzed patient data. Authors NM, GE, DR and SZ contributed to writing the manuscript. All authors read and approved the final manuscript.

Acknowledgements

This work was supported by a Collegium Talentum scholarship from the Ministry of Human Capacities (Hungarian Government), for the 2021/2022 and 2022/2023 academic years.

Competing interests

Not applicable.

Funding

Not applicable.

References

1. Jamshidi R. Central venous catheters: indications, techniques, and complications. Semin Pediatr Surg. 2019;28:26-32.
2. Machat S, Eisenhuber E, Pfarl G, Stübler J, et al. Complications of central venous port systems: a pictorial review. Insights Imaging. 2019;10:86.
3. Müller-Ortiz H, Pedreros-Rosales C, Silva-Carvajal JP, et al. Prevalence of complications associated with central venous catheter instalation for hemodyalisis. Rev Med Chil. 2019;147:458-64.
4. Bell J, Goyal M, Long S, et al. Anatomic site-specific complication rates for central venous catheter insertions. J Intensive Care Med. 2020;35:869-74.
5. Timsit JF. What is the best site for central venous catheter insertion in critically ill patients? Crit Care. 2003;7:397-9.
6. Pikwer A, Baath L, Davidson B, Perstoft I, Akeson J. The incidence and risk of central venous catheter malpositioning: a prospective cohort study in 1619 patients. Anaesth Intensive Care. 2008;36:30-7.
7. American Society of Anesthesiologists. Practice guidelines for central venous access 2020. An upated report by the American Society of Anesthesiologists Task Force on central venous access. Anesthesiology. 2020;132:8-43.
8. Bridges KG, Welch G, Silver M, Schinko MA, Esposito B. CT detection of occult pneumothorax in multiple trauma patients. J Emerg Med. 1993;11:179-86.
9. Safety Committee of Japanese Society of Anesthesiologists. Practical guide for safe central vein catheterization and management 2017. J Anesth. 2020;34:167-86.
10. Millington SJ, Lalu MM, Boivin M, Koenig S. Better with ultrasound: subclavian central venous catheter insertion. Chest. 2019;155:1041-8.
11. Brass P, Hellmich M, Kolodziej L, Schick G, Smith AF. Ultrasound guidance versus anatomical landmarks for internal jugular vein catetherization. Cochrane Database Syst Rev. 2015;1:CD006962.
12. Parmar MS. (F)utility of "routine" postprocedural chest radiograph after hemodialysis catheter (central venous catheter) insertion. J Vasc Access. 2021;22:4-8.
13. Zanobetti M, Coppa A, Bulletti F, et al. Verification of correct central venous catheter placement in the emergency department: comparison between ultrasonography and chest radiography. Intern Emerg Med. 2013;8:173-80.
14. Smit JM, Raadsen R, Blans MJ, Petjak M, Van de Ven PM, Tuinman PR. Bedside ultrasound to detect central venous catheter misplacement and associated iatrogenic complications: a systematic review and meta-analysis. Crit Care. 2018;22:65.