Guidewires unintentionally retained during arterial and central venous catheterization

Vizient Patient Safety Organization Safety Alert

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Background

Millions of central venous catheters are inserted into patients every year to perform hemodialysis, monitor hemodynamics, and administer fluids, medications and nutritional support.[1] Arterial catheterization is frequently performed on high-risk surgical and critically ill patients requiring continuous monitoring of blood pressure, frequent blood sampling and blood gas analysis.[2] A number of mechanical complications can occur during central venous or arterial line insertion, some of which include kinking, looping, or knotting of the guidewire, breakage or fracture of the guidewire, recognized or unrecognized loss of the wire during the procedure, and entrapment of the wire in the catheter or a previously placed intravascular device such as inferior vena cava (IVC) filters.[3-13] The exact incidence of retained central line guidewires is unknown, but Vannucci, et al., reported a rate of one case per a few thousand catheter insertions.[6] The loss or retention of a guidewire can result in arrhythmia, vascular damage, thrombosis, embolism, infection, cardiac perforation and tamponade, or death.[10,14,15]

Assessment

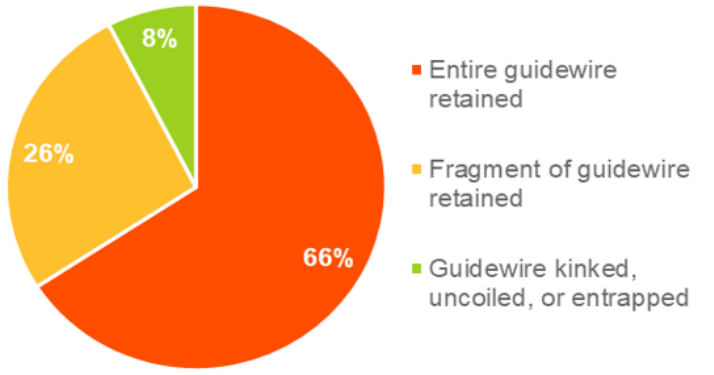
Objective

The Vizient® Patient Safety Organization (PSO) conducted a retrospective analysis of event reports involving retained central line guidewires to highlight their persistence, common causes and outcomes, and identify system improvements to prevent their occurrence. This analysis replicates a previous one in 2013 by Vizient PSO (formerly University HealthSystem Consortium (UHC) PSO) which described 42 reported cases.[3]

Findings

From January 2017 through March 2021, a search of the Vizient PSO database yielded 77 event reports involving a retained central venous or arterial line guidewire. Of those events, 51 (66%) involved an entire guidewire accidentally left in the patient, 20 (26%) involved a fragment of a wire, and 6 (8%) involved a guidewire that was entrapped in the catheter or kinked or uncoiled (near misses) during the procedure (Figure 1).

Figure 1. Description of guidewire issue

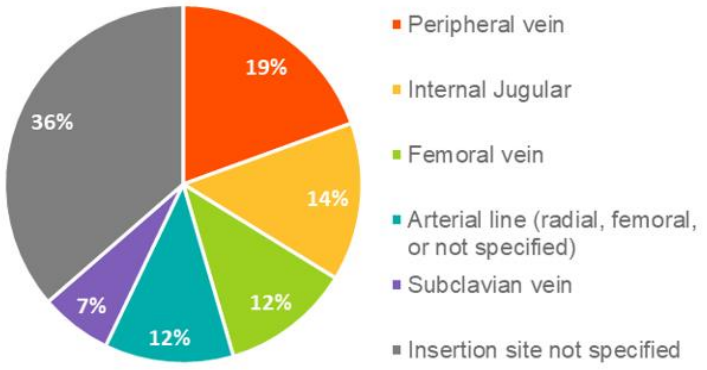


Data Source: Vizient Patient Safety Organization
Period of data: January 2017 - March 2021; number of events = 77

Site of insertion

Of the 77 events in this analysis, 68 events involved a venous catheterization and 9 events involved arterial insertion. The site of venous or arterial line insertion was described in 49 events (Figure 2).

Figure 2. Site of venous or arterial line insertion



Data Source: Vizient Patient Safety Organization
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Location involved

The locations that most commonly reported retained CVC guidewires were intensive care units (43%). Other locations were operating rooms or procedural areas (17%), emergency departments (17%), and other acute care units (12%). The remaining occurred in outpatient areas or were unknown.

Circumstances surrounding the discovery and length of retention

In 47% of events, the clinician became aware of the retained or entrapped, kinked, or uncoiled guidewire during or immediately following the procedure and actions were taken to remove the guidewire or fragment before closure. Since The Joint Commission considers an unintentionally retained foreign object during surgery or an invasive procedure a sentinel event any time after the completion of final skin closure, these events were not likely acted upon as sentinel events.[16]

In 39% of events, the retained guidewire went unnoticed at the end of the procedure, and it was discovered later in the hospital stay or visit. In 8% of events, the retained guidewire was discovered after discharge or during a subsequent visit. Retained guidewires were discovered on imaging tests ordered postprocedure (25%) or imaging tests ordered for other medical reasons, including symptoms related to the retained guidewire (10%). In 9% of events, the guidewire was noted in the port during treatment, change, or removal. Retained guidewires were discovered days, weeks, or months after retention before removal. Seventy-five percent of all events required additional treatment or caused temporary or permanent harm. Information surrounding how and when the retained guidewire was discovered and the outcome was not available in several events.

Contributing factors

A commonly used technique for inserting central lines that is considered quite safe when properly applied is the Seldinger (catheter-over-wire) technique; however, it is associated with the occurrence of retained guidewires.[3,10,15,17,18] The technique involves inserting an introducer needle into the vein, advancing a guidewire through the needle, removing the needle, and then advancing the catheter over the guidewire. Once the catheter is in place, the guidewire is removed. The guidewire directs the placement of the catheter and allows smooth advancement and navigation around bends in vessels, reducing the risk of vessel injury as well as air embolization. The Seldinger technique has a higher rate of successful catheterization than other methods.[3,17,18]

There are a couple key reasons that central line guidewires are lost or break during insertion. First, there is no mechanism in the design that allows the clinician to effectively secure the proximal end of the wire during insertion. Since the end of the guidewire that the clinician holds onto is straight, the guidewire can be inadvertently advanced into the patient with the catheter. Maintaining grasp on proximal end of the wire may be difficult when the clinician needs both hands to advance the catheter, is reaching for instruments, responding to distractions or emergencies, or if the patient moves suddenly.[3,5,17] Breakage or shearing of the wire may occur due to poor insertion technique or lack of experience or training. A common guidewire design is a straight central core wire that is wrapped with an outer layer of coiled wire. During insertion if the clinician feels resistance and pulls back on the wire, the guidewire can catch or lock on the bevel of the introducer needle, particularly if the wire becomes bent or kinked. When the wire locks with the needle, it can cause breakage or shearing of the wire.[3,10-12] After the procedure, wire retention should be suspected if the wire or a piece of the wire is missing, there is resistance to injection or poor venous back-flow from the distal lumen, or a guidewire is seen on the post-procedure imaging test.[3,15]

Similar to the events reported in the literature[3-6], the factors that contributed to retained guidewires in these event reports included:

- No forcing function to prevent loss or ensure removal. The proceduralist lost hold of wire during procedure while threading the catheter over the wire which sometimes went unnoticed.
- Work environment including emergency situations, distractions and interruptions.
- Equipment quality and function or a difficult insertion or entrapment of the wire.
- Lack of clinician experience.
- Lack of supervision.
- Procedure performed by a solo provider without another person to double check that the wire was removed or inaccurate documentation that the guidewire was removed.
- Radiologist missed the retained wire on review of the imaging test.
- Multiple central line kits and guidewires were used during a procedure.
- Patient-related factors such as movement.
- Human factors such as inattention, poor technique or fatigue.

Other significant findings in the literature

Another important descriptive study of 73 sentinel events submitted to The Joint Commission that involved retained guidewires during insertion of vascular catheters, devices used during surgery, and drainage tubes further highlights the seriousness of this issue. In almost 40% of the cases, the retained guidewires were not identified until after hospital discharge and four patients died as a result of a retained central line guidewire.[4]

Recommendations

Organizational strategies to prevent retained guidewires

Training, supervision, and privileges:

- Train providers inserting devices with guidewires using simulation, including forced-error detection and competency assessment.[4,19]
- Educate about the risk of losing the guidewire during insertion and the need to inspect its integrity before insertion and on removal to ensure that it is intact, particularly if resistance is encountered on withdrawal.[3-6,10,15,20]
- Educate clinicians that, in general, the guidewire should not be withdrawn through the needle because of the risk of shearing. If the guidewire needs to be removed while the needle is still in place, the guidewire and needle should be withdrawn together as a unit.[3,10] A bent guidewire should immediately be replaced with a new one.[3]
- Educate clinicians that they should not advance the guidewire further than necessary, especially if fluoroscopy is not used. Less than 20 cm of guidewire in the vein of an adult is adequate under most circumstances.[3,4,6,10]
- Educate clinicians to check if the patient has an intravascular device prior to the procedure to ensure measures are taken to prevent wire entrapment such as placing the line under fluoroscopic guidance.[10]
- Develop standards for the supervision of less experienced clinicians.[3]
- Establish privileging policies that set thresholds for training and experience in the placement of central and arterial lines.[3,4]

Standardization

- Standardize central line kits to eliminate errors due to variations in kits.[4,17,20]
- Implement policies and procedures requiring two-person verbal and written verification of removal and integrity of guidewires and documentation.[4-6,17]
- Conduct post procedure imaging on central and arterial line insertions and ensure the procedure is noted on the request for the study.[4,17]
- Develop standard work for the radiologist that includes checking for a guidewire or wire fragment and documenting in the findings that a wire was not present or present.[6,17]
- Require a verbal report from the radiologist to the provider if a guidewire is identified on x-ray and use high priority alerts.[4]
- Expand the use of fluoroscopy during central line placement.[17]

Redundancy, checklist, and double checks

- Require a two-person procedure—an operator and an observer—to ensure all pertinent steps of the procedure are completed including removal and integrity of the guidewire.[3-5,20] Empower staff to remind the clinician to secure the end of the wire, to monitor for loss, and to stop the procedure if the wire becomes bent, broken or lost.[3-5,15,17]
- Implement a central line checklist that includes documentation of the removal of the guidewire and inspection of its integrity before and after the procedure by both the operator and observer. Note whether the patient has a pre-existing intravascular device prior to the procedure.[3-5,10,17]

Central line kit design and forcing functions

Factors contributing to these events such as distractions, emergency situations, and accidental loss suggest the need for stronger actions including the redesign of devices and kits and forcing factors.[5,13,17,19]

- Evaluate various central and arterial line products including the strength and length of the guidewire or forcing functions in its design to prevent loss or unrecognized loss of the wire. Central line insertion kits are variable, and some catheters come with longer or shorter guidewires. Using guidewires that are longer would allow more of the wire to extend beyond the hub, possibly lessening the risk of loss.[3]
- Purchase central and arterial line kits with stronger guidewires to reduce the possibility of breakage.[3,4]
- Contact manufacturers to learn about how they are addressing the issue of guidewire loss or breakage such as:
    - Central line guidewires that have distance markings.[3,10]
    - The kit includes measuring tape so that it can be measured at the end of the procedure.
    - The distal tip of the guidewire (end inserted into the patient) has a distinguishing characteristic (e.g., texture) so that breakage can be identified when it is removed.[3,11]
    - The proximal end of the guidewire (external end) is brightly colored or has a distinct tactile sensation that alerts the clinician the end of the wire is near.[3,4,17]
    - There is a reminder to remove the guidewire before accessing the suture needle in the kit; for example, a sticker over the needle.[3,4,17]
    - Mariyaselvam, et al., designed a novel locked procedure pack to prevent unrecognized loss of the wire. The feature contains the equipment (e.g., suture, suture holder, and antimicrobial dressings) required to complete the procedure after the guidewire should have been removed. The guidewire is used as a key to unlock the pack and to access the contents; thereby, the clinician must remove the guidewire from the patient to complete the procedure. This design prevents the unrecognized loss of the guidewire so that it can be removed prior to wound closure and prevent longer term retention (a sentinel event).[19]

Guidewire retrieval

In most cases, the entire wire or fragment can be retrieved.

- If catheter has not been fully inserted, carefully feel for the guidewire inside the catheter by pinching it. If the wire is felt, carefully place a clamp about a centimeter or so below the end of the guidewire. Slowly pull the catheter completely out to where the wire can be seen at the skin. Grasp the wire with another clamp or fingers and then pull the whole assembly out slowly.
- If the guidewire is completely inside the patient and cannot be retrieved, place a sterile dressing, get a plain film to confirm its retention, call interventional radiology,[3,14,15] and inform the patient or family.

Ongoing monitoring and surveillance

To improve our understanding of the frequency of retained central line guidewires and causal factors, encourage clinicians to report near misses and events that reach the patient, whether or not the patient was harmed. For better aggregation of data, capture data under a specific event type such as provided in Vizient's 3-tiered proprietary taxonomy as follows: event related to surgery or invasive procedure, foreign body accidentally left in the patient, and guidewire. Monitor compliance with policies and procedures for central line insertion.[4] Include process and outcome measures in your surveillance dashboard (Table 1) to monitor compliance with standard work and inform your organization of impending risks.

Table 1. Quality measures for central line insertions

Volume	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**T/E**
# central lines inserted													
Process													
% of cases wire removed with inspection and pre-post-measurement of the guidewire documented													
% of chest x-rays document no retained guidewire													
% of CL independent double-checks of removal documented													
% of privileged clinicians with no central line insertion procedures in 12 months													
% of central lines inserted under emergency situations													
# of CL inserted by residents without supervision													
Outcomes													
# of retained central line guidewires (whole wire or fragment) per 100 CL inserted													

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References

1. McGee DC, Gould MK. Preventing complications of central venous catheterization. *N Engl J Med.* 2003;348(12):1123-1133. doi:10.1056/NEJMra011883
2. Weiner R, Ryan E, Yohannes-Tomicich J. Arterial line monitoring and placement. In: Oropello JM, Pastores SM, Kvetan V. eds. *Critical Care*. McGraw Hill; . Accessed March 11, 2022. https://accessanesthesiology.mhmedical.com/content.aspx?bookid=1944&sectionid=143522170
3. Williams TL, T. Bowdle A, Winters BD, Pavkovic SD, Szekendi MK. (2014). Guidewires unintentionally retained during central venous catheterization. *JAVA – Journal of the Association for Vascular Access*. 19(1):29-34. https://doi.org/10.1016/j.java.2013.12.001
4. Steelman VM, Thenuwara K, Shaw C, Shine L. Unintentionally retained guidewires: A descriptive study of 73 sentinel events. *Jt Comm J Qual Patient Saf*. 2019;45(2):81-90. doi:10.1016/j.jcjq.2018.08.003
5. Cherara L, Sculli GL, Paull DE, Mazzia L, Neily J, Mills PD. Retained guidewires in the Veterans Health Administration: Getting to the root of the problem. *J Patient Saf*. 2018 Feb 13. doi: 10.1097/PTS.0000000000000475. Epub ahead of print. PMID: 29443720.
6. Vannucci A, Jeffcoat A, Ifune C, Salinas C, Duncan JR, Wall M. Special article: retained guidewires after intraoperative placement of central venous catheters. *Anesth Analg*. 2013;117(1):102-108. doi:10.1213/ANE.0b013e3182599179
7. Arnous N, Adhya S, Marof B. A Case of Retained Catheter Guidewire Discovered Two Years After Central Venous Catheterization. *Am J Case Rep*. 2019;20:1427-1433. Published 2019 Sep 28. doi:10.12659/AJCR.915941
8. Abdel-Aal AK, Saddekni S, Hamed MF. Guide wire entrapment in a vena cava filter: techniques for dislodgement. *Vasc Endovascular Surg*. 2013;47(2):115-123. doi:10.1177/1538574412471209
9. Kusminsky RE. Complications of central venous catheterization. *J Am Coll Surg*. 2007;204(4):681-696. doi:10.1016/j.jamcollsurg.2007.01.039
10. Khasawneh FA, Smalligan RD. Guidewire-related complications during central venous catheter placement: a case report and review of the literature. *Case Rep Crit Care*. 2011. doi:10.1155/2011/287261.
11. Monaca E, Trojan S, Lynch J, Doehn M, Wappler F. Broken guidewire—a fault of design? *Can J Anaesth*. 2005;52(8):801-804.
12. Suzuki T, Ito K, Nishiyama J, Hasegawa K, Kanazawa M, Fukuyama H. Development of a safe guidewire. *J Anesth*. 2006;20(1):64-67.
13. Mariyaselvam MZA, Patel V, Young HE, Blunt MC, Young PJ. Central venous catheterguidewire retention: Lessons from England's never event database. *J Patient Saf*. 2021 Jan 26. doi: 10.1097/PTS.0000000000000826. Epub ahead of print. PMID: 33512864.
14. Bream PR Jr, Heffernan DS, Shukrallah B. Retrieval of a wire lost during central venous catheter replacement: a case report using a new technique for wire retrieval and a review of the literature. *Endovascular Today*. May 2008;38-41. Available at http://bmctoday.net/evtoday/pdfs/EVT0508_03.pdf. Accessed January 17, 2022.

15. Schummer W, Schummer C, Gaser E, Bartunek R. Loss of the guide wire: mishap or blunder?. *Br J Anaesth*. 2002;88(1):144-146. doi:10.1093/bja/88.1.144
16. Sentinel Events. The Joint Commision. Updated July 2021. Accessed January 17, 2022. .https://www.jointcommission.org/-/media/tjc/documents/resources/patient-safety-topics/sentinel-event/camh_24_se_all_current.pdf.
17. Lum TE, Fairbanks RJ, Pennington EC, Zwemer FL. Profiles in patient safety: misplaced femoral line guidewire and multiple failures to detect the foreign body on chest radiography. *Acad Emerg Med*. July 2005;12(7):658-662. Accessed January 17, 2022. https://onlinelibrary.wiley.com/doi/epdf/10.1197/j.aem.2005.02.014.
18. Lin C-Y, Hsu Y-J, Hong G-J, Tsai C-S, Lin S-H. Guidewires Unintentionally Retained During Central Venous Catheterization: Broken guidewire during subclavian venous catheterization. *Dial Transplantation*. 2006;35(8):536-537.
19. Mariyaselvam MZA, Catchpole KR, Menon DK, Gupta AK, Young PJ. Preventing retained central venous catheter guidewires: A randomized controlled simulation study using a human factors approach. *Anesthesiology*. 2017;127:658–665. doi: https://doi.org/10.1097/ALN.0000000000001797
20. Horberry T, Teng YC, Ward J, Patil V, Clarkson PJ. Guidewire retention following central venous catheterisation: a human factors and safe design investigation. *Int J Risk Saf Med*. 2014;26(1):23-37. doi:10.3233/JRS-140610

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