Diagn Interv Radiol 2017; 23:238–244

INTERVENTIONAL RADIOLOGY

PICTORIAL ESSAY

Unintentionally retained vascular devices: improving recognition and removal

Gilbert Whang
Ilya Lekht
Rita Krane
Greg Peters
Suzanne L. Palmer

ABSTRACT

The increased demand for minimally invasive placement of intravascular medical devices has led to increased procedure-related complications, including retention of all or part of the implanted device. A number of risk factors can predispose to unintentionally retained vascular devices (uRVD); most are technical in etiology. Despite best efforts to insert and remove vascular devices properly, uRVD still occur. Prevention or early identification of uRVD is ideal; however, procedural complications are not always recognized at the time of device insertion or removal. In these cases, early radiologic diagnosis is important to enable expeditious removal and reduction of morbidity, mortality, and medicolegal consequences. The diagnostic radiologist's role is to identify suspected uRVD and ensure proper communication of the findings to the referring clinician. The diagnostic radiologist can implement various strategies to increase detection of uRVD and advise the referring clinician regarding the use of minimally invasive percutaneous techniques for safe removal of uRVD.

Increased utilization of minimally invasive intravascular devices has led to an increased number of procedure-related complications (1). Catheter fragmentation and embolization; retained guidewire fragments; migrated coils, stents, inferior vena cava filters; and other unintentionally retained vascular devices (uRVD) are well-documented complications (1, 2). Early diagnosis is important to enable expeditious removal prior to the development of adverse consequences. Because procedural complications are not always recognized at the time of insertion, the diagnostic radiologist should examine every vascular device with uRVD in mind. In order to improve uRVD detection, the radiologist should take into account medical and procedural histories and account for every nonbiologic finding on the study with routine windowing and magnification of images to aid detection (3).

Adverse events associated with uRVD may be medicolegal and financial. Medical consequences include sepsis, vessel perforation/thrombosis, embolism, cardiac arrhythmias, and death (1, 2, 4). Review of case review and case report publications between 2000 and 2012 demonstrated that the percentage of symptomatic patients ranged up to 5.6% in case review publications and up to 32% in case report publications (5).

Medical errors and the associated financial and medicolegal implications are well publicized to the lay public in the United States. In 2002, the National Quality Forum (NQF) created a list of serious reportable but preventable events, known as Never Events, in order to drive systematic national improvements in patient safety. An uRVD is one of these Never Events (6). In response to the NQF communication, the Centers for Medicare & Medicaid Services began denying reimbursements for medical care related to delayed retrieval of medical devices and complications related to these devices (7). In the European Union, unintended retention of foreign bodies is a reportable figure with prevalence from 0.5–11.6 per 100 000 medical/surgical discharges (8).

Technical factors that may predispose to uRVD include using inappropriate techniques for placement or removal of devices; inappropriate supervision of trainees performing placement or removal procedures; and manufacturing device defects. Patient factors include performing a procedure on an unstable or uncooperative patient and patient anatomy. Uncontrolled patient motion may result in excessive traction force leading to device fragmentation (4). In the case of subclavian venous devices, compression of the catheter by the subclavian muscle-costoclavicular ligament may lead to positional cath-

From the Department of Radiology (G.W. ✉ *whangg@med.usc.edu*) Keck School of Medicine of the University of Southern California, Los Angeles, California, USA.

Received 29 July 2016; revision requested 31 August 2016; revision received 28 September 2016; accepted 10 October 2016.

Published online 31 March 2017.
DOI 10.5152/dir.2017.16369

eter dysfunction, catheter fatigue, fragmentation, and possible embolization (9).

The diagnosis of uRVD is best made at the time of the procedure; however, if it is identified first on postprocedural imaging, the finding should be promptly communicated with the referring clinical service. The contact should be documented in the radiology report, including the name of the clinician contacted and date/time of the notification (10). Delay in or incomplete communication of uRVD may increase the risk of serious adverse events. Expeditious removal of uRVD is recommended. Percutaneous retrieval of uRVD by an interventional radiologist is safe and effective, with several case series demonstrating success rates from 90%–97% (2, 11). The US Food and Drug Administration (FDA) recommends discussion with the patient regarding the risks and benefits of retrieving versus leaving uRVD in place (12). The discussion should include the composition, size, and location of uRVD; potential harm if left in place; and the procedures or treatments that should be avoided if left in place. The FDA recommends that the device should be saved and the manufacturer notified of the device failure (12). Further, hospital and other facilities must report deaths or serious injuries associated with the medical device(s) (12).

Minimally invasive retrieval procedures are preferred over surgery due to lower rate of complications, which include inability to engage or withdraw chronic uRVD, distal embolization of uRVD, arrhythmia, sepsis, and vessel injury (1, 2, 5, 13). Minor complications reported include

Main points

- Increased utilization of intravascular medical devices has led to an increased number of device-related complications.
- Routine windowing and magnification of images aids in detection of unintentionally retained vascular devices (uRVD).
- The finding of uRVD should be communicated directly with the referring clinician and that notification should be documented in the clinical record.
- Minimally invasive percutaneous retrieval of uRVD has been well established and preferred over surgical removal.
- Cases of uRVD should be evaluated individually with regard to retrieval planning.

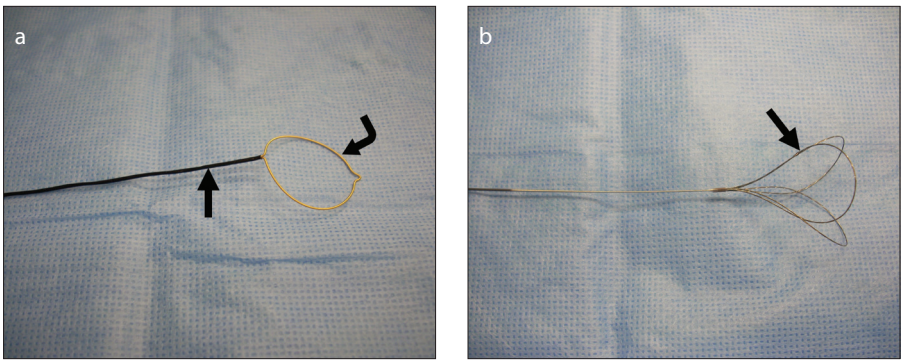

Figure 1. a, b. Examples of loop snare. Amplatz GooseNeck Snare (**a,** Covidien) is a guidewire-like device with a loop snare *(curved arrow)* inserted through the catheter *(arrow)*. The snare loop forms at a 90° angle and the loop size is flexible and easily changed. EN Snare (**b,** Merit Medical Systems, Inc.) features three interlaced loops *(arrow)* providing more vessel coverage to assist with capture and retrieval of unintentionally retained vascular devices (uRVD).

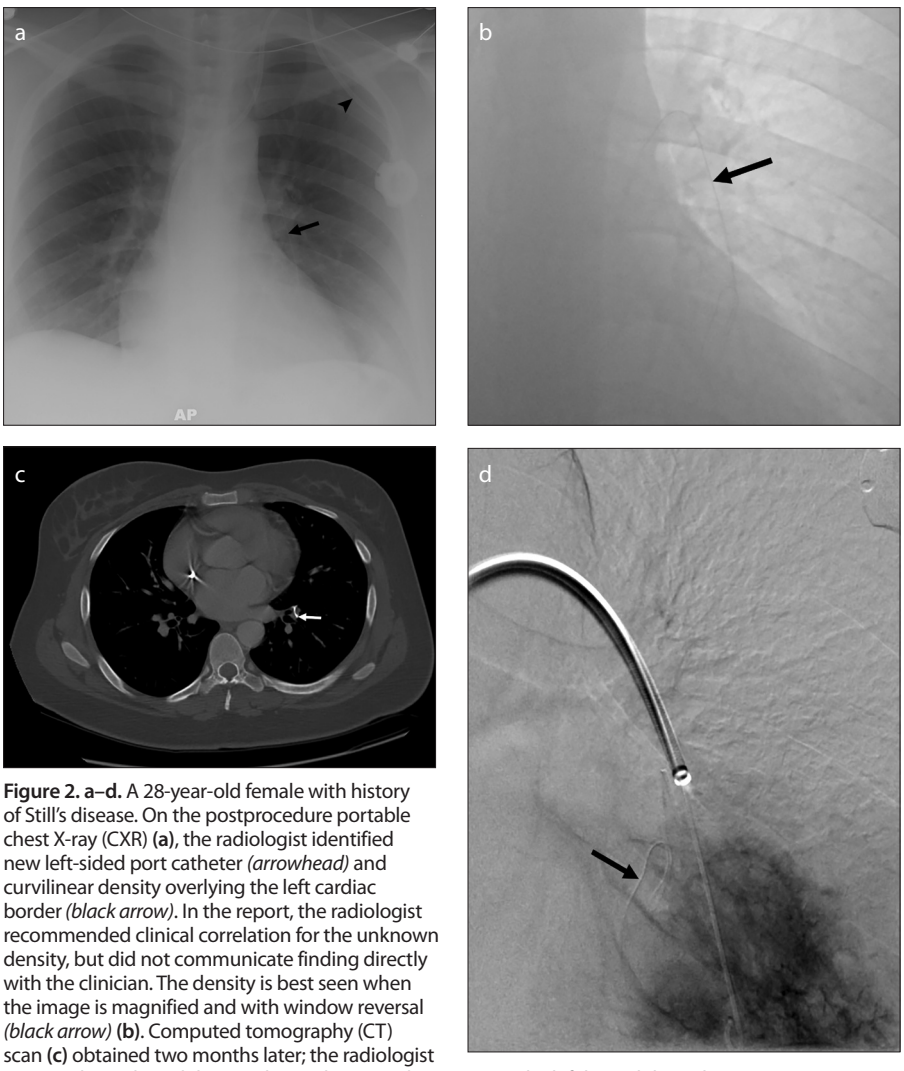

Figure 2. a–d. A 28-year-old female with history of Still's disease. On the postprocedure portable chest X-ray (CXR) **(a)**, the radiologist identified new left-sided port catheter *(arrowhead)* and curvilinear density overlying the left cardiac border *(black arrow)*. In the report, the radiologist recommended clinical correlation for the unknown density, but did not communicate finding directly with the clinician. The density is best seen when the image is magnified and with window reversal *(black arrow)* **(b)**. Computed tomography (CT) scan **(c)** obtained two months later; the radiologist incorrectly attributed the curvilinear density *(white arrow)* in the left lower lobe pulmonary artery to sequelae of chronic pulmonary embolism. Nine months later, a 2-view CXR (not shown) was obtained. The radiologist identified the presumed wire fragment and immediately contacted the referring clinician, who elected to proceed with minimally invasive removal as the patient was symptomatic. The patient had acknowledged to her clinician about having ongoing episodes of left-sided pleuritic chest pain. Interventional radiology was consulted and using right common femoral vein approach, the left pulmonary artery branches were selectively catheterized **(d)**. Using a combination of EN® MeritMedical snare and loop snare devices, the wire fragment *(black arrow)* was retrieved without complication. Patient did not have further episodes of pleuritic chest pain.

hemoptysis, hematomas, and hypertensive episodes (1, 2, 11, 13). Vascular access by surgical cutdown may be necessary when complete removal is not possible (1). Relative contraindications to retrieval include uncorrectable bleeding diathesis or large, free-floating thrombus attached to uRVD. Factors to consider in the decision to retrieve uRVD include patient's life expectancy, symptomatology, likelihood of major complications, and hazards of retrieval (5). Not all uRVD should be removed. Cases should be evaluated individually and the risk/benefit ratio should be considered before attempting to retrieve uRVD. Surgical consultation may be obtained if percutaneous methods are unsuccessful.

Retrieval of uRVD starts with procedure planning, including careful review of prior imaging. Vascular access site is determined by the location of uRVD. Route of retrieval should be considered depending on vessel branch points and sharp bends (14). Geometry and size of uRVD factor into the choice of retrieval devices used. Many intravascular retrieval devices are available, including loop snares, grasping retrieval forceps, and helical baskets.

The loop snare (Fig. 1) is the most common choice for retrieval due to good safety profile. It is useful when uRVD have a free end or a doubled over segment which can be surrounded (14). Nitinol shape memory of the wire loops helps to prevent wire kinks (1). The diameter of the loop snare should be equal to or smaller than the vessel diameter.

A number of techniques using the loop snare can be implemented to capture uRVD (14). The proximal grab technique is a basic method whereby withdrawing the outer catheter allows the loop snare to be opened fully and surround uRVD. Distal wire grab, coaxial snare, and lateral grasp techniques incorporate usage of a stiff wire, which is passed through or around uRVD. The wire and/or uRVD can be captured with a loop snare before removal. Small balloon technique, which can be used for stent retrieval, involves a guidewire which traverses through or part of uRVD to help guide a noncompliant balloon catheter within or distal to uRVD. Grasping retrieval forceps are useful for items lacking an accessible free end, but due to their rigidity, they carry a risk of perforation. The helical basket, commonly used in the biliary system, can expand and open up to capture uRVD. Its utility is limited by difficulty in guiding the device, and the rigid tip can pose risk of vessel damage.

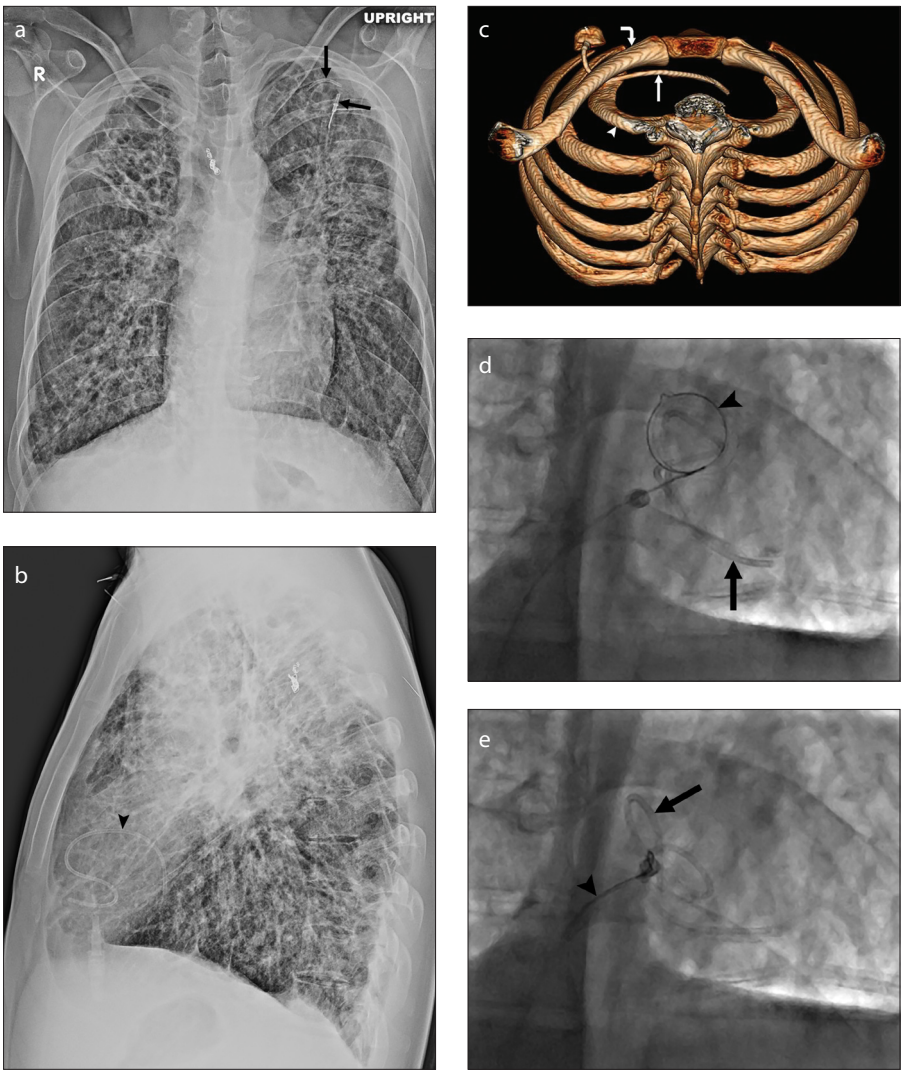

Figure 3. a–e. A 23-year-old male with history of cystic fibrosis exacerbation. Windowed posteroanterior (PA) **(a)** and lateral **(b)** views of the chest demonstrate two catheter fragments *(black arrows)* near the port hub and a distal fractured fragment that embolized to the right heart *(black arrowhead)*. Vitrea (Vital Images, Inc.) workstation volume rendering **(c)** from a CT scan performed a year before the fracture demonstrates port catheter *(white arrow)* coursing in a tight space between the clavicle *(curved arrow)* and the first rib *(white arrowhead)*. The radiologist correctly identified the three fracture fragments on CXR, spoke directly with the referring clinician, and documented the notification in the radiology report. To prevent future embolization of the fragment resulting in potential complications including arrhythmias, interventional radiology was consulted and the catheter fragment within the right atrium (RA) was successfully removed. Spot image during retrieval **(d)** depicts distal catheter fragment *(black arrow)* within the RA and an Amplatz GooseNeck Snare (Covidien) *(black arrowhead)* positioned around the fragment. Second spot image **(e)** depicts snare *(black arrowhead)* tightened around the catheter fragment *(black arrow)*, which was then withdrawn into the guiding sheath and removed from the patient. There were no procedural complications during the retrieval. The two proximal fragments in the left anterior chest wall were removed several days later. Chronic, repetitive catheter compression, as in this case, can lead to catheter fracture (pinch-off syndrome). Placement of catheter more laterally in the subclavian vein can help prevent catheter fatigue and fracture from occurring.

The following clinical cases encountered in our institution will illustrate the typical appearance of the most common uRVD found in practice and review the minimally invasive interventional techniques to retrieve them. The types of uRVD seen in our practice are similar to those found in multicenter trial of other institutions (15). Several mimics of uRVD will also be illustrated.

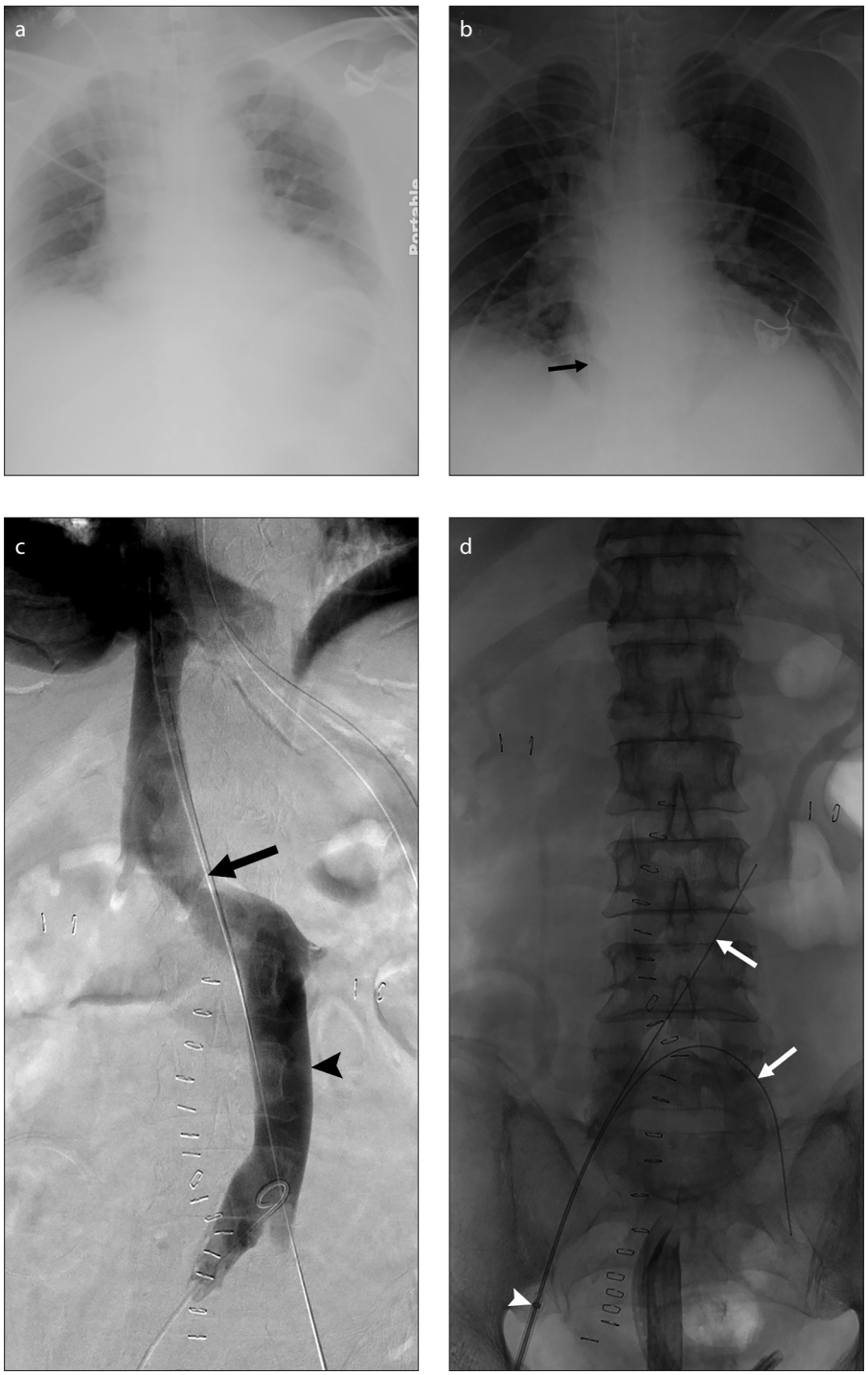

Figure 4. a–d. A 65-year-old male with a history of rectal cancer, status post low anterior resection. Postsurgical, underexposed portable CXR **(a)** demonstrated normal support lines and catheter. Portable CXR with improved technique **(b)** obtained three days later demonstrates radiopaque linear density *(black arrow)* overlying the right atrium/inferior vena cava, which was interpreted as a retained guidewire, likely from prior central line placement. The radiologist directly notified the referring clinician and documented the interaction in the dictated report. In retrospect, the retained guidewire can be seen on the initial portable CXR with dynamic windowing of the film. Interventional radiology was consulted for minimally invasive retrieval procedure to prevent future embolization of the wire resulting in complications including arrhythmias. Right common femoral vein was accessed and cavography **(c)** demonstrated retained guidewire *(black arrow)* within a persistent left-sided inferior vena cava *(black arrowhead)*. A pigtail catheter was used to create a loop around the retained wire and then using a snare loop device, the wire *(white arrows)* was encircled and both snare loop and wire were retracted through 6 F guiding sheath *(white arrowhead)* **(d)**. There were no procedural complications. The core problem in the case is underutilization of dynamic windowing, especially on portable intensive care unit films. Visualization of all medical devices and diagnosis of uRVD are nearly impossible on an underexposed CXR without manipulating the window levels.

Clinical cases

Case 1 (Fig. 2) of a 28-year-old female with history of Still's disease highlights two core problems: image interpretation (failure to identify uRVD on portable chest X-ray [CXR] and computed tomography [CT] scan) and lack of communication with referring clinician about an unknown overlying density resulting in delay of diagnosis.

Case 2 (Fig. 3) of a 23-year-old male with history of cystic fibrosis exacerbation depicts an example of the pinch-off syndrome.

Case 3 (Fig. 4) of a 65-year-old postsurgical male highlights the importance of dynamic windowing during interpretation of radiographs.

Case 4 (Fig. 5) of a 58-year-old male with unresectable metastatic cholangiocarcinoma highlights problem with image interpretation and the importance of being cognizant of the appropriate positioning of vascular devices on imaging, as complications may arise over time.

Case 5 (Fig. 6) of a 57-year-old male with a long cardiac history depicts complications related to insertion of a vascular device due to other indwelling medical devices and how minimally invasive techniques can rectify the complication.

Case 6 (Fig. 7) of a 55-year-old male with history of cholecystectomy highlights a case of hepatic artery aneurysm coils embolizing to adjacent bile ducts, which were removed through biliary procedure and surgery.

Mimics

Not all radiopaque curvilinear densities represent uRVD. There are many mimickers of retained vascular devices that may appear on imaging. These include, but are not limited to, overlying jewelry, electrocardiography lines, artifacts from radiograph cassette, and surgical masks (Fig. 8). Patient's altered surgical anatomy could also produce a mimic of uRVD (Fig. 9). Intravenous contrast jet through a power peripherally inserted central catheter can mimic a retained wire fragment on CT scans (Fig. 10). Becoming familiar with the appearance of known medical devices and uRVD can eliminate some of the misdiagnoses.

Conclusion

With the increased utilization of minimally invasive vascular devices, compli-

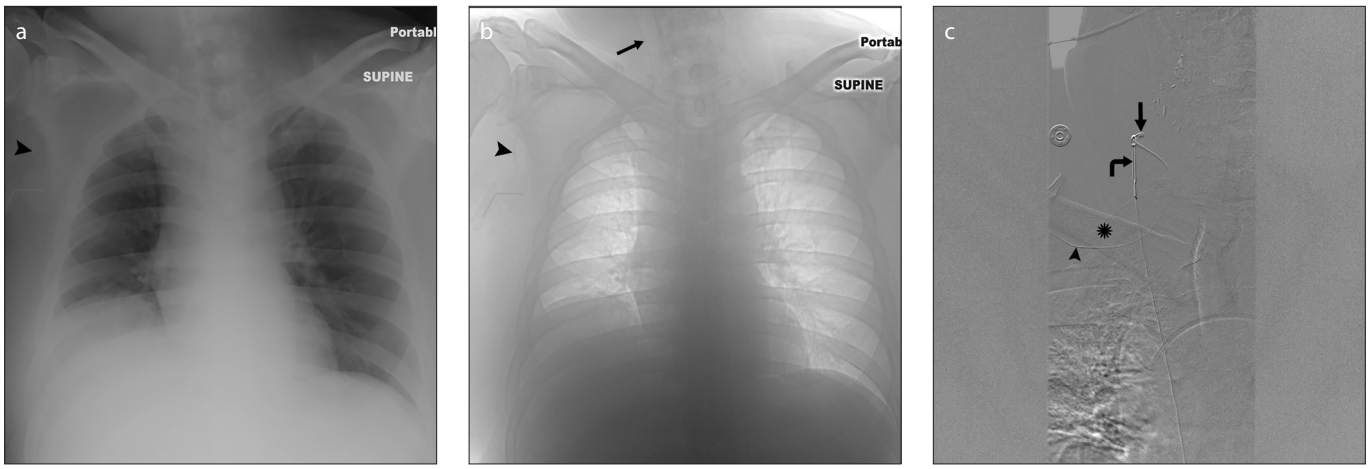

Figure 5. a–c. A 58-year-old male with history of metastatic cholangiocarcinoma, status post L4 corpectomy, intervertebral implant and lumbar fusion. A postoperative portable CXR **(a)** demonstrates a port catheter *(arrowhead)* in the right side of the chest, but the radiologist failed to recognize that the distal end was positioned cranially in the right internal jugular vein. After reverse windowing **(b)**, the distal end *(arrow)* of the port catheter can be more easily seen to be malpositioned in the right internal jugular vein. The finding was recognized on a CXR three days later and communicated with the referring surgical team, who elected for minimally invasive intervention. Interventional radiology repositioned the distal end of the catheter into the cavoatrial junction to improve the function of the catheter and prevent possible complication of clot formation in the internal jugular vein. Subtraction image from right femoral approach port catheter repositioning procedure **(c)** demonstrates a snare device *(curved arrow)* closed around the distal end of the port catheter tip *(arrow)*. Note that the proximal aspects of the catheter *(arrowhead)* are within the expected location of subclavian vein inferior to the clavicle *(star)*. The tip was subsequently repositioned into the cavoatrial junction (not shown). The core problem in this case was the failure to recognize the location of the distal end of the port catheter in the right internal jugular vein. One should be cognizant of appropriate positioning of vascular medical devices whenever interpreting radiology studies.

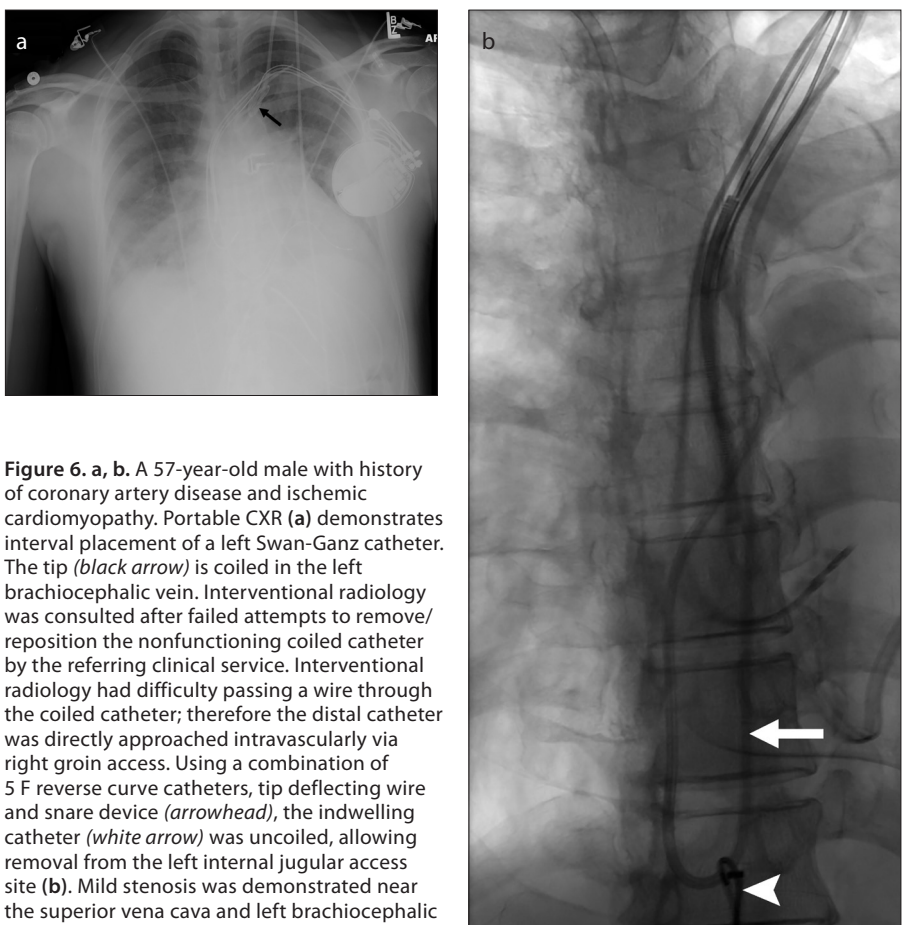

Figure 6. a, b. A 57-year-old male with history of coronary artery disease and ischemic cardiomyopathy. Portable CXR **(a)** demonstrates interval placement of a left Swan-Ganz catheter. The tip *(black arrow)* is coiled in the left brachiocephalic vein. Interventional radiology was consulted after failed attempts to remove/reposition the nonfunctioning coiled catheter by the referring clinical service. Interventional radiology had difficulty passing a wire through the coiled catheter; therefore the distal catheter was directly approached intravascularly via right groin access. Using a combination of 5 F reverse curve catheters, tip deflecting wire and snare device *(arrowhead)*, the indwelling catheter *(white arrow)* was uncoiled, allowing removal from the left internal jugular access site **(b)**. Mild stenosis was demonstrated near the superior vena cava and left brachiocephalic confluence, likely related to indwelling pacemaker leads (not shown). The core problem in the case was difficulty with placement of the catheter secondary to preexisting, indwelling pacemaker leads that limited the intraluminal space, leading to coiling of the catheter and difficulty in its subsequent repositioning and removal.

cations such as device fragmentation, embolization, and malposition have increased. Early diagnosis is important to enable expeditious removal and reduction of medicolegal consequences.

The diagnostic radiologist's role is to identify suspected uRVD and ensure proper communication of the findings to the referring clinician (10). All medical and procedural histories should be taken into account when interpreting imaging studies. Every nonbiologic finding on the study should be accounted for, utilizing dynamic windowing and magnification routinely (3). If there is a diagnostic question or an equivocal finding, direct communication with the referring clinical service is strongly recommended and the threshold for obtaining additional radiographs or cross-sectional imaging should be lowered.

Percutaneous retrieval of uRVD has been well established in clinical practice and in the literature. Success rates of percutaneous retrieval exceed 90% (2, 11) and given low rates of minor complications (1, 2, 11, 13), minimally invasive interventional techniques should be preferred over surgical removal. Cases of uRVD should be evaluated individually with consideration of the risk/benefit ratio prior to attempting retrieval.

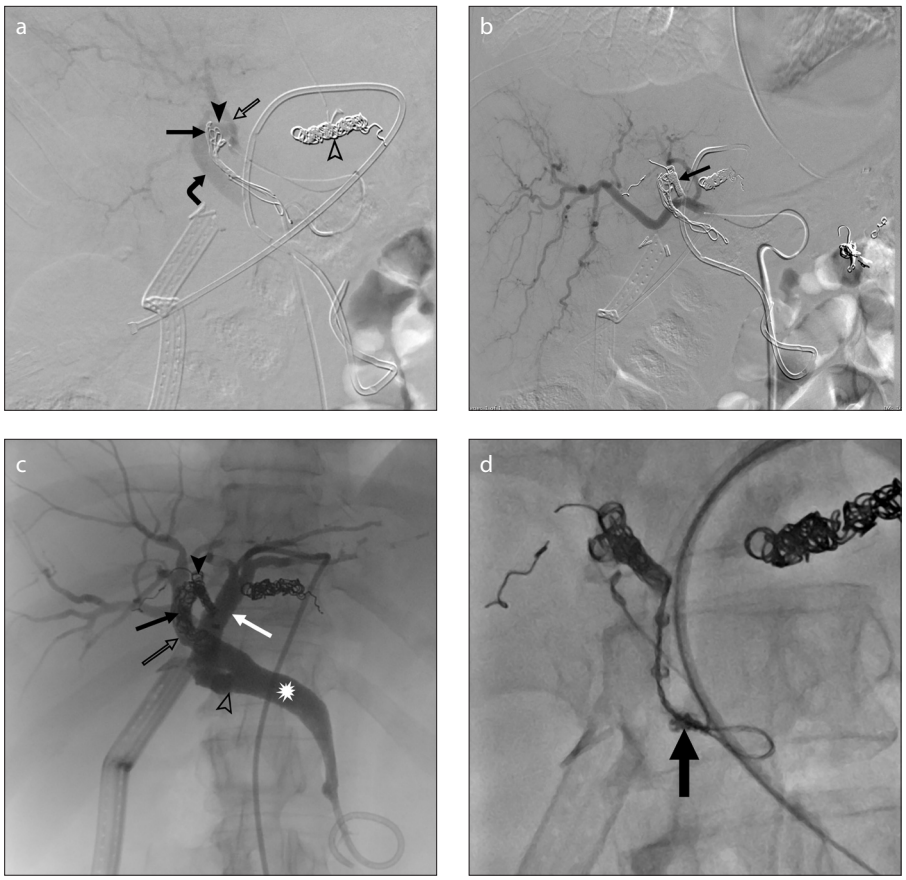

Figure 7. a–d. A 55-year-old male with history of chronic pancreatitis and cholecystectomy complicated by bile leak and hemobilia. Interventional radiology was consulted for coil embolization of hepatic artery pseudoaneurysm and biliary fistula. Right femoral access angiogram **(a)** demonstrates pseudoaneurysm *(arrowhead)* at bifurcation of anterior division of right hepatic artery *(open arrow)* with fistulous connection to right hepatic bile duct stump *(curved arrow)*. Adjacent curvilinear radiodensities were interpreted as a possible retained surgical sponge *(black arrow)*. Incidental noted was made of prior embolization coils *(open arrowhead)* in the left hepatic lobe. Postembolization image **(b)** demonstrates coils *(black arrow)* within the pseudoaneurysm and branches *(black arrow)* of the anterior division of the right hepatic artery. Cholangiogram **(c)** through biliary drain demonstrated persistent bile leak (not shown) and filling of both right *(open arrow)* and left *(white arrow)* bile ducts and an aberrant course of the left bile duct, crossing anterior to the right bile ducts and inserting laterally *(open arrowhead)* to form the common hepatic duct *(white star)*. Lateral to recently placed embolization coils *(black arrowhead)* were curvilinear radiodensities *(black arrow)*, erroneously diagnosed as retained surgical sponge, which represented embolization coils within the right bile duct. They had fistulized into the right biliary system from prior embolization procedure of the hepatic artery. Interventional radiology was reconsulted for removal of the coils in the biliary system **(d)** as they could be a nidus for bile duct stone formation. An EN® MeritMedical snare was used to twist the coils *(black arrow)* around the snare and the majority of the coils were removed. A residual coil was removed during patient's subsequent Roux-en-Y hepaticojejunostomy to repair the defect in the left hepatic duct, sustained during outside hospital cholecystectomy.

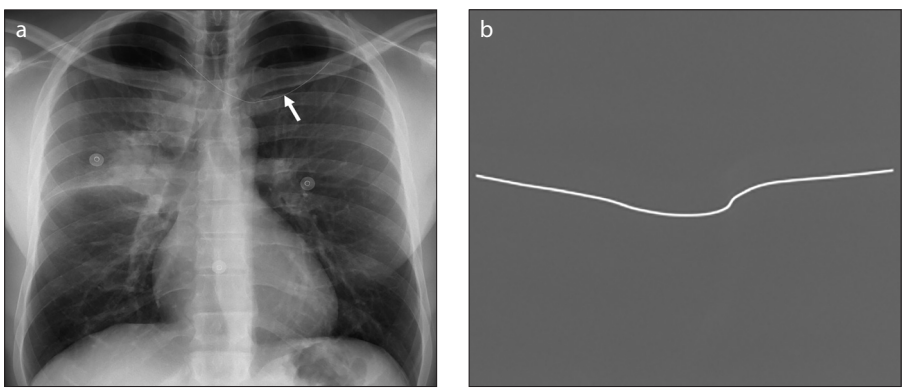

Figure 8. a, b. A 22-year-old male with cough and neutropenia. This patient's surgical mask mimics uRVD. CXR **(a)** demonstrates curvilinear density *(arrow)* overlying the clavicles. Radiograph of a Kimberly-Clark So Soft mask **(b)** (Kimberly-Clark Professional) demonstrates the metallic portion.

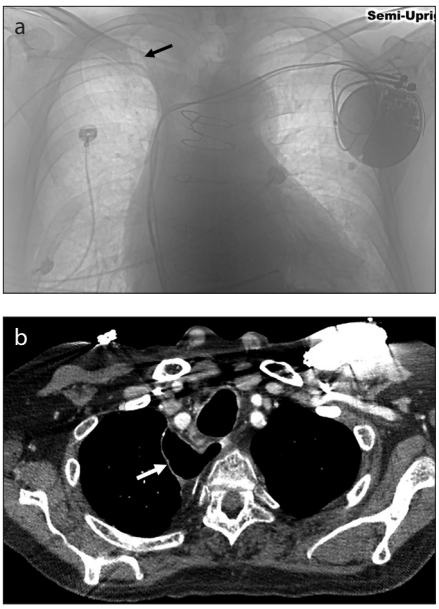

Figure 9. a, b. A 58-year-old female with history of gastric pull-up and pleural effusion. Gastric pull-up mimicking uRVD. Windowed portable CXR **(a)** demonstrates a linear density in the right paratracheal location *(black arrow)*. Chest CT scan **(b)** confirms that the linear density on the CXR represents the gastric pull-up *(white arrow)* and not uRVD.

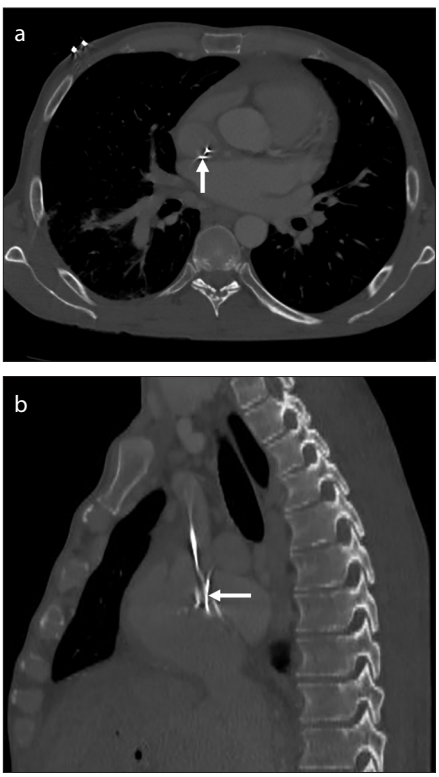

Figure 10. a, b. A 33-year-old male with history of chronic pancreatitis. Contrast jets from power peripherally inserted central catheter (PICC) mimicking uRVD. CT chest scan **(a)** demonstrates a curvilinear hyperdensity *(arrow)* representing contrast jet posterior to the PICC. Sagittal reformatted images **(b)** demonstrates the same uRVD mimic *(arrow)* in addition to other contrast jets adjacent to the tip of the PICC.

Conflict of interest disclosure

The authors declared no conflicts of interest.

References

1. Wolf F, Schernthaner RE, Dirisamer A, et al. Endovascular management of lost or misplaced intravascular objects: experiences of 12 years. Cardiovasc Intervent Radiol 2008; 31:563–568. [Crossref]
2. Gabelmann A, Kramer S, Gorich J. Percutaneous retrieval of lost or misplaced intravascular objects. AJR Am J Roentgenol 2001; 176:1509–1513. [Crossref]
3. Whang G, Mogel GT, Tsai J, Palmer SL. Left behind: unintentionally retained surgical placed foreign bodies and how to reduce their incidence. AJR Am J Roentgenol 2009; 193:S79–89. [Crossref]
4. Tateishi M, Tomizawa Y. Intravascular foreign bodies: danger of unretrieved fragmented medical devices. J Artif Organs 2009; 12:80–89. [Crossref]
5. Schechter MA, O'Brien PJ, Cox MW. Retrieval of iatrogenic intravascular foreign bodies. J Vasc Surg 2013; 57:276–281. [Crossref]
6. National Quality Forum. Serious Reportable Events. Cited June 2016. Available from: http://www.qualityforum.org/Topics/SREs/Serious_Reportable_Events.aspx
7. Sack K. Medicare won't pay for medical errors. The New York Times. 2008 Oct 1.
8. OECD/European Union. Procedural or postoperative complications. In: Health at a Glance: Europe 2014. Paris: OECD Publishing, 2014; 94–95.
9. Hinke DH, Zandt-Stastny DA, Goodman LR, Quebbeman EJ, Krzywda EA, Andris DA. Pinch-off syndrome: a complication of implantable subclavian venous access devices. Radiology 1990; 177:353–356. [Crossref]
10. ACR Practice Guideline for Communication of Diagnostic Imaging Findings. Cited June 2016. Available from: http://www.acr.org/~/media/C5D1443C9EA4424AA12477D1AD1D927D.pdf
11. Egglin TK, Dickey KW, Rosenblatt M, Pollak JS. Retrieval of intravascular foreign bodies: experience in 32 cases. AJR Am J Roentgenol 1995; 164:1259–1264. [Crossref]
12. FDA Public Health Notification: Unretrieved Device Fragments. Cited June 2016. Available from: http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm062015.htm
13. Savage C, Ozkan OS, Walser EM, Wang D, Zwischenberger JB. Percutaneous retrieval of chronic intravascular foreign bodies. Cardiovasc Intervent Radiol 2003; 26:440–442. [Crossref]
14. Woodhouse JB, Uberoi R. Techniques for intravascular foreign body retrieval. Cardiovasc Intervent Radiol 2013; 36:888–897. [Crossref]
15. Moffatt-Bruce SD, Ellison EC, Anderson HL 3rd, et al. Intravascular retained surgical items: a multicenter study of risk factors. J Surg Res 2012; 178:519–523. [Crossref]