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Case Report

Troubleshooting for Kinked Coronary Catheter: How to Manage?

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ABSTRACT

Background: Catheter entrapment and knotting are two problems that might arise during coronary angiography, regardless of the method used. It is not uncommon for the catheter shaft to become kinked during diagnostic or interventional procedures. Still, if the manipulation fails, an invasive retrieval method is usually necessary for cases with extensive catheter kinking.
Case Illustration: We present two cases illustrating how different angiography approaches could lead to severe catheter kinking. Because of the significant tortuosity of the vasculature, even a gentle opposite rotation maneuver and the antegrade advancement of multiple guidewires failed to untwist the guide catheter. Once a twisted catheter has been identified via fluoroscopy, the twist can be eased by gently twisting the catheter in the opposite direction. It is not always easy. It could lead to using other interventional techniques such as snare, balloon, or surgical procedures. In our cases, we used a snare to snag the catheter's tip and untied the loop's knot. This prevented the need for unscheduled surgical intervention. We evaluated from angiography. There were no further complications. The patients were released from the hospital the following day.
Conclusion: Although a kinked catheter could become entrapped, various approaches can be taken to deal with this difficulty and prevent the need for surgical intervention.

1. Introduction

The transfemoral technique is preferred over the transradial. Because of its accessibility, short radiation period, and low contrast, Due to its lower risk of bleeding, fewer vascular problems, faster recovery time, earlier discharge, patient preference, and reduced risk of morbidity and death, the transradial technique has become the standard for interventional and diagnostic cardiology procedures in the last two decades.[1] Catheter entrapment and knotting are two problems that might arise during coronary angiograms regardless of the method used. It is not uncommon for the catheter shaft to become kinked during diagnostic or interventional procedures.[2]

However, this is usually unlocked by crossing the catheter with a standard or hydrophilic wire straightening the catheter. Vascular entrapment can occur when a catheter deforms to a greater degree. When this manipulation fails, an invasive retrieval method is usually necessary for cases with extensive kinking.[3] Here, we detail two successful retrievals of a highly deformed catheter with repeated kinking that had been lodged, each using a unique approach and set of tools.

2. Case Illustration

2.1 Case report 1

A 77-year-old male with risk factors of hypertension, an active smoker, and a history of acute coronary syndrome a month ago, still developed symptoms of exertional angina and dyspnoea on effort. He underwent coronary angiography through the 7-French sheath, but a 6-French JR guide catheter failed to engage the right coronary artery. During fluoroscopy, the evaluation showed severe tortuous at the right iliac artery and severe knotted of the guide catheter. Because of the significant tortuosity of the vasculature, even a gentle opposite rotation maneuver and the antegrade advancement of multiple guidewires failed to untwist the guide catheter.

We tried to change to left transfemoral access, but the left iliac artery was tortuous. We decided to use the right trans-radial approach by the 6-French sheath, and the angiogram showed tortuous at the right subclavian artery. We used a snare catheter 15mm, snared from the proximal tip of the knotted catheter was pulled up into the subclavian artery.

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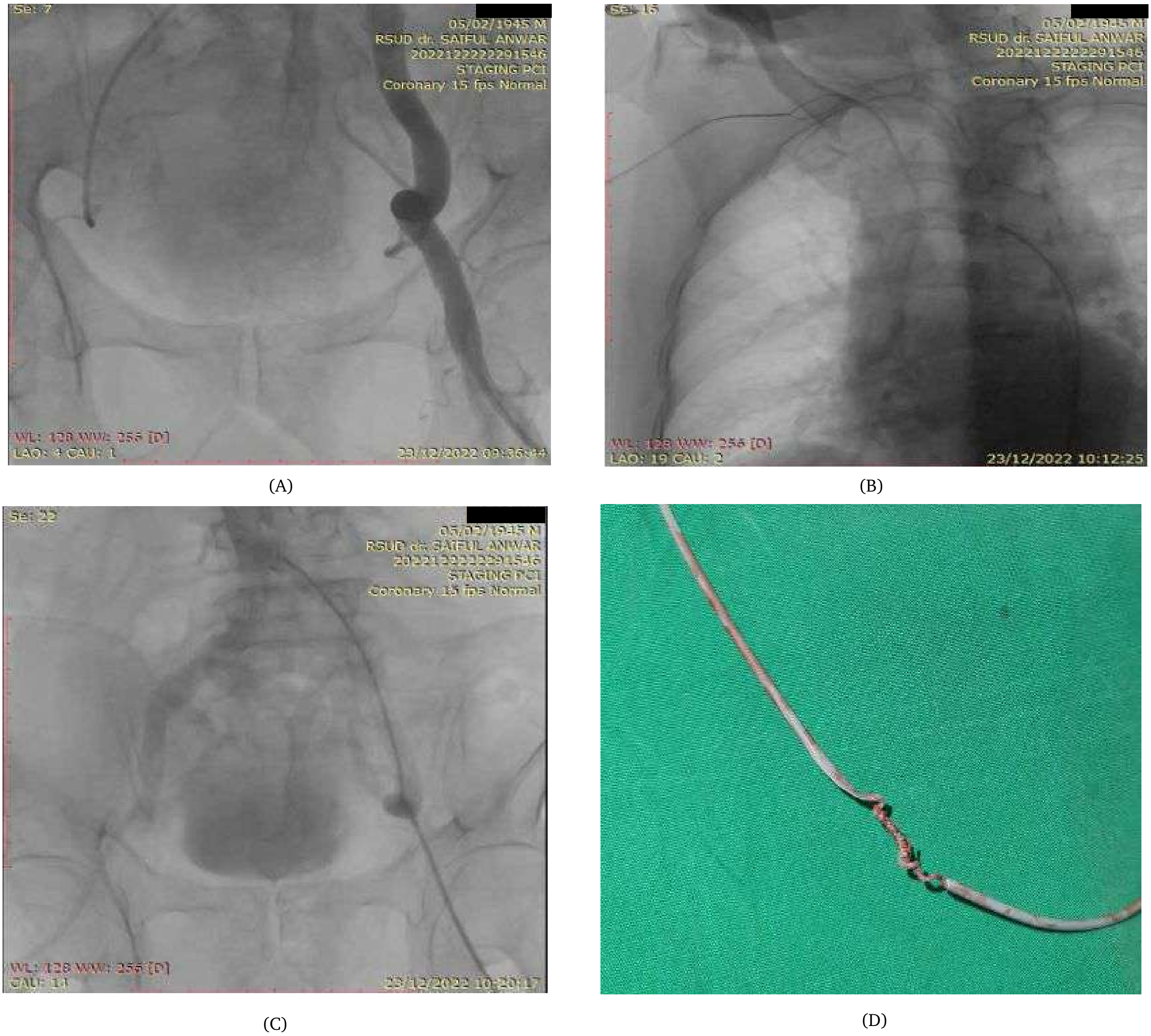


Figure 1. (A and B) Under fluoroscopy, kinked catheter at femoral dextra, tried to pulled out from trans femoral access sinistra but angiography showed tortuous at femoral sinistra (C) Under fluoroscopy, knotted catheter was pulled out by using snare delivery technique from trans radial access (D) The knotted catheter was pulled out

To ensure the catheter tip was securely fastened, we rotated it gently after knotting it. At last, we untangled the tangled transfemoral catheter and pulled it out of the right femoral vein. No vascular problems were seen when we compared the aortography of the left femoral artery to that of the right femoral artery. We resumed percutaneous coronary intervention (PCI) through the left femoral artery, which was completed successfully. The entire fluoroscopic time was 20 minutes, and 110mL of contrast material was used. There were no complications during the treatment, and the patient was released two days later.

2.1 Case report 2

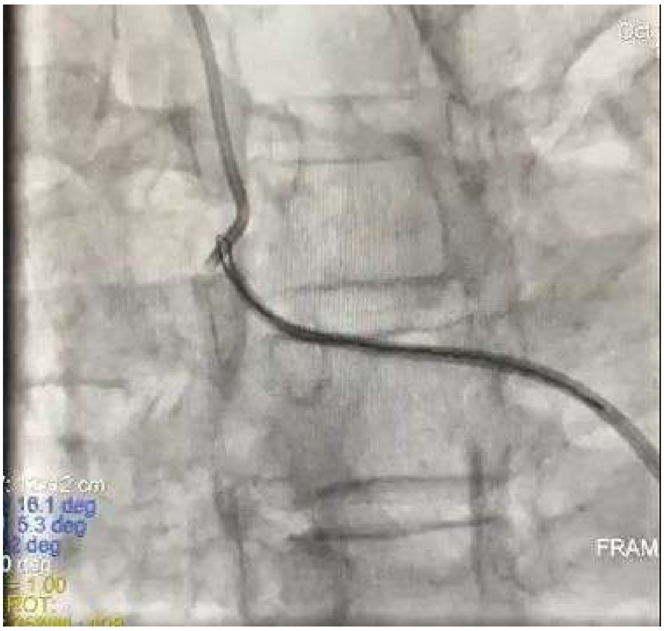
A 67-years old male with risk factors of hypertension and a history of smoking underwent coronary angiography through a transradial approach by the 6-French sheath. During fluoroscopy, an evaluation showed catheter entrapment of the antebrachial artery. We did a gentle opposite rotation maneuver to retrieve the catheter. We decided to use a transfemoral approach by the 7-French sheath and snared from the proximal tip of the knotted catheter with gentle rotation to the knotted catheter, confirming fixation of the catheter tip. Then we straightened and retrieved the catheter from the right transradial access. We evaluated from angiography that there were no further complications. The patient was released from the hospital the following day without complications.

3. Discussion

3.1 Access approach of PCI

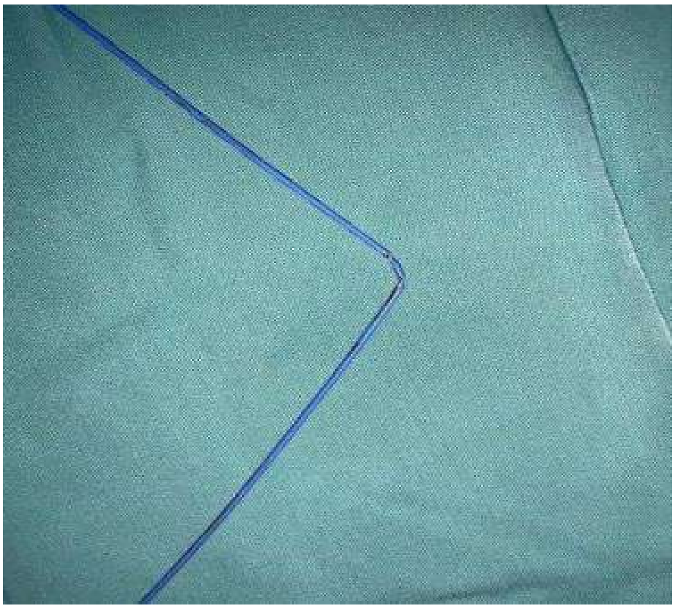
In interventional cardiology, transradial intervention (TRI) has been a game-changer. Early ambulation, improved postoperative comfort, and a reduced risk of site access problems are all advantages of TRI. Evidence shows that “TRI reduces mortality in patients presenting with ST-elevation myocardial infarction (STEMI)

(A)



(B)

(C)



(D)

Figure 2.(A) Kinked catheter at antebrachia dextra (B) Catching the tip of wire with snare (C) Angiography evaluation after successful untwist of the kinked catheter (D) Twisted catheter successfully removed.

"Radial access is recommended as the access strategy for cardiac catheterization at "a Class I (level of evidence A) level in the 2017 guidelines from the European Society of Cardiology".[4] Reduced "patient discomfort, major bleeding rate, hospital stay, and time to mobilization" are just a few of how this new treatment excels above the standard transfemoral (TF) method. The transradial technique, initially developed for coronary treatments, is now also used for visceral and peripheral procedures.5 It is becoming increasingly apparent that TRA, rather than FA, may be preferable as the default approach due to the adverse effects of peri-procedural bleeding and access-site problems on results and costs to health systems. According to a recent study, the use of TRA for PCI has increased significantly. However, it is still not widely used (5%).[6]

3.2 Complication

However, the TR method presents more significant technical challenges due to the smaller diameter of the arteries in the arms. Due to the dual blood supply of the hand, problems from accidental injury to the radial artery, such as dissection or thrombosis, are extremely rare. There is a larger risk of catheter looping or kinking with TR access compared to the conventional transfemoral access site, which is the primary concern for some of the operators. Catheter entrapment and significant vascular injury may result if this happens, and it is not usually straightforward to resolve.[5] The trans-radial method has several drawbacks, such as a more complicated access route (particularly in the subclavian and brachiocephalic arteries) and the possibility of the catheter kinking due to extreme rotation. Although counter-rotation is typically used to straighten a knotted catheter, the shaft may be fractured if the catheter has been rotated excessively, rendering counter-rotation ineffective.[7]

3.3 Kinked catheter

A catheter used frequently and worn down over time is more susceptible to kinking. Factors like spasm, severe tortuosity or looping, accidental torquing, and the smaller size of the downstream artery facilitate catheter kinking or twisting. Catheter kinking manifests itself in various ways, including the disappearance of the pressure waveform, reduced torque, and increased injection resistance. Once a twisted catheter has been identified via fluoroscopy, the twist can be eased by gently twisting the catheter in the opposite direction. Guidewire is often all that's needed for simple control. After the twist is released, the catheter is removed, and a new one is inserted.[8]

Using a catheter designed for a femoral approach, the tortuosity of the vasculature, severe torquing and manipulation of the catheter, and even vasospasm are all possible causes of kinking resulting in immobility. Coronary catheters are typically designed for transfemoral access. However, many are now being used for trans-radial approaches. Since the RRA is the preferred access site, the pre-shaped catheter must be rotated so that it can "cross the S-shaped morphology of the right subclavian-innominate aorta".[9]

This causes additional delays in the treatment and causes the catheter to be handled more than necessary.[10] Subclavian tortuosity and excessive manipulation increase resistance and reduce the efficiency of a force's application. This increases the potential for downstream kinking and looping.[5] A significant muscle component in addition to alpha-1 receptors likely causes vasospasm, leading to entrapment, if more brutal manipulation is used to alleviate the loop in the brachial or radial arteries.[9]

However, when looping is involved, retrieving the catheter becomes problematic. Patient referrals for surgical removal of a knotted catheter have been documented in the literature.[11] Retrieval of a tangled catheter has been detailed by more authors than can be counted. Kim JY reported successfully rescuing an entangled catheter using a snare kit and a right femoral approach. Waked A said that he successfully removed a catheter from his brachial artery on another occasion.[9] The proximal end of the catheter was severed, and a longer sheath was inserted into the kink with "the trapped catheter serving as a guidewire." The long sheath was then advanced to the kink, and the trapped catheter was gently withdrawn to unfurl its loop and slide into the sheath. Omar AM also reported one such retrieval using the mother-and-child approach and a larger guiding catheter.[12]

Table 1. Tips to Prevent Catheter Kinking.[17]

1. Remain cognizant of vascular tortuosity, while performing catheter manipulations.
2. Avoid torquing catheters more than 180°
3. Maintain a guidewire through the catheter.
4. Pay close attention to loss of torque, pressure waveform, or an inability to aspirate a catheter.
5. Take care when using catheters smaller than 6-F in caliber because they may be more prone to kinking.
6. Consider using a long sheath if extensive vascular tortuosity is noted.
7. Consider a left radial artery approach because of the lower prevalence of left-sided brachiocephalic tortuosity, especially in older adults.

Table 2. Summary of Various Techniques to Retrieve Kinked and Trapped Coronary Catheters

Blood pressure cut inflation on ipsilateral brachial region followed by gentle unwisting of catheter (4)
Amplatz Goose Neck Snare (Boston Scintific, Maarlborough, massachusetts) to catch tip of catether, followed by unraveling of knot in a large-caliber vessel (5)
EN Snare catether (Merit Medical Systems, South Jordan, Utah) to captute distal tip of kinked catheter, followed by twisting of distal and proximal ends of kinked catheter in opposite directions to unravel knot (6)
Cutting hub of catheter, placing long sheath over catheter, and dragging kinked segment into the sheath to straighten (7)
Balloon-assisted trapping and removal of kinked catheter through a large-bore sheath

3.3.1 Prevalence of knotted catheter

It is not uncommon for a catheter to get somewhat looped or kinked while being manipulated; however, this is easily remedied by rotating the catheter in the other direction. Once in a while, this looped or knotted catheter can become stuck, necessitating a more invasive procedure to free it.[9] "Catheter infections occurred in 7.74 per 1000 catheter days, affecting 38.61% of patients, catheter dysfunction occurred in 10.58 per 1000 catheter days, affecting 56.65% of patients, and central vein stenosis occurred in 0.68 per 1000 catheter days, affecting 8.79% of patients".[13]

3.3.2 Prevention

Looping can be avoided in several ways, such as not performing TRA on the left radial artery (LRA), not rotating the catheter more than 180 degrees, keeping the guidewire in place, and keeping a close eye on the pressure tracings. RRA is preferred over TRA by 90% of interventional cardiologists. Ten percent of patients undergoing transradial access (TRA) for coronary procedures have severe right subclavian tortuosity, and the RRA has double the incidence of operator-reported mild subclavian tortuosity compared to the LRA. Subclavian tortuosity raises the difficulty of catheter manipulation and lengthens the duration of the procedure. As a result, using the LRA as the access site can shorten the procedure's duration, lessen the need for unnecessary manipulation, lessen resistance, boost one-to-one torque, and perhaps decrease downstream looping.[9]

If you keep the catheter from turning more than 180 degrees, you won't generate any proximal torque that gets lost on the way to the tip.7 Therefore, it is possible to avoid looping and kinking since distal catheter control is improved and unexpected proximal catheter behavior is reduced. Looping can be avoided by closely monitoring the pressure curve as the torque is applied. Additional torque could again cause unexpected catheter behavior when partial attenuation of the pressure curve indicates a lack of advancement. Keeping a guidewire inside the catheter has also been suggested by many operators as a way to improve one-to-one torque.[14]

3.3.3. Technique

External compression to stabilize the distal part of the knotted catheter, insertion of a larger long sheath with a typical guidewire, and insertion of a balloon catheter or vascular snare are all alternatives if the kinking cannot be eliminated with simple counter rotation of the catheter. The complexity of the deformity makes balloon catheter or snare fixation the only viable option for treatment.[15]

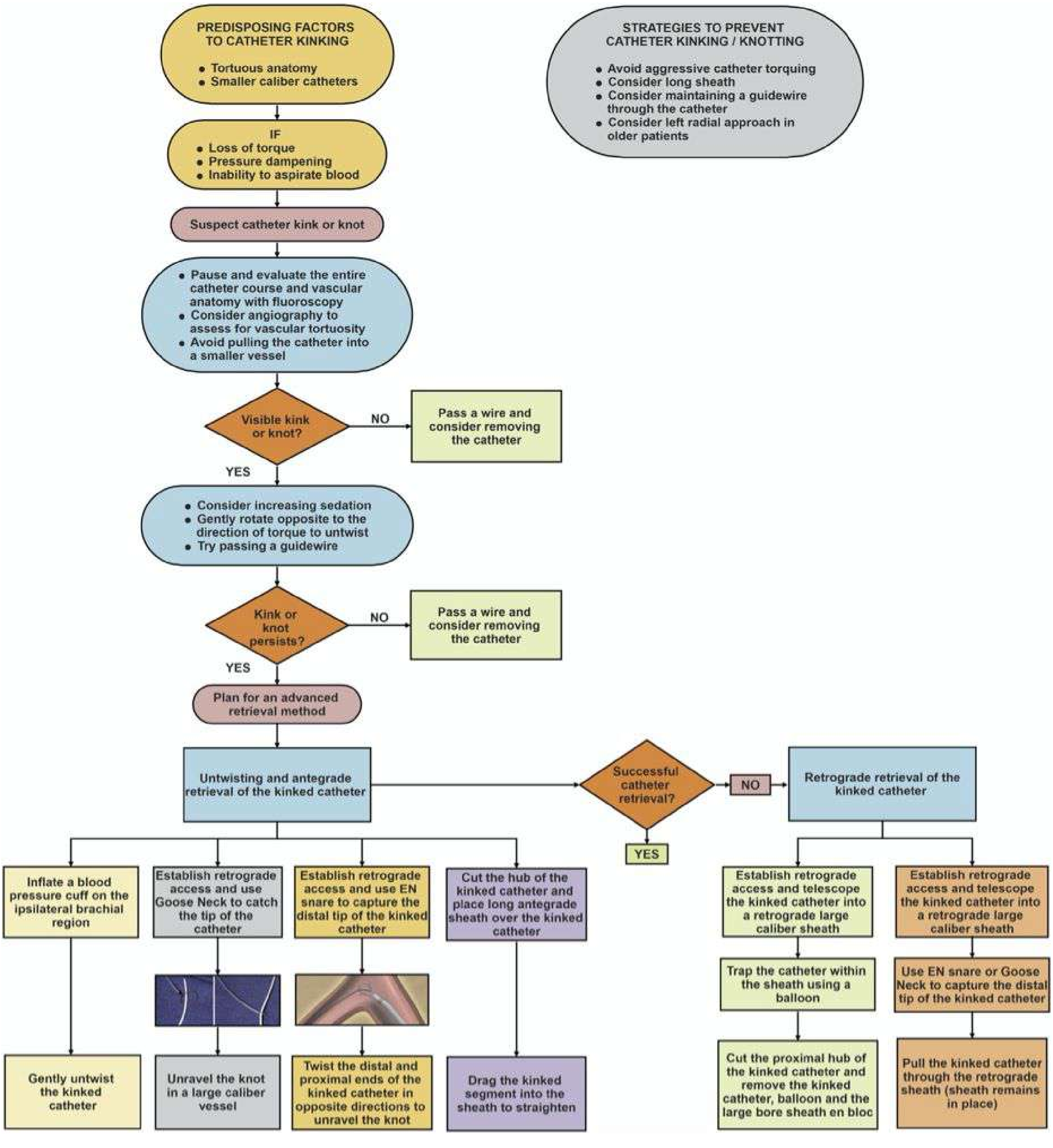


Figure 3. Algorithm for Management of Catheter Kinking

Several methods and step-by-step algorithms have been described for untying a knotted and stuck catheter. Attempts to remove the snare using gentle counterclockwise rotation, advancing a firm wire into the loop, delivering the snare via a femoral approach, and the balloon retrieval technique were all fruitless. Because the knot was so far upstream, other published approaches, such as external fixation of the distal catheter with a sphygmomanometer cuff, long sheath, and sheathless techniques, were not applicable in our circumstance.[16]

To prevent further vascular complications from the femoral artery, a 6-Fr guiding catheter was utilized during the anastomosis of the bypass graft. The inner lumen of a 6-Fr system is large enough to accommodate a 4-mm gooseneck snare and a 0.014-in. coronary guidewire, notwithstanding the recommendations of recent articles that suggest "using 7-Fr or larger-sized guiding catheters for retrieval with snare". It was previously believed that larger arteries like the subclavian artery or thoracic aorta were too big for a 4-mm snare put in the brachial artery to trap the catheter tip successfully.[15]

Balloon internal fixation of a 5F angiographic catheter was a straightforward, practical, and cost-effective approach for minimizing artery injury and avoiding surgical intervention. It gave us an alternative way to deal with catheter knotting.

However, it is critical that the catheter not become kinked. If the rotation rate is too high, the torque response will suffer. Patients with a convoluted aortosubclavian system are also recommended to undergo catheter manipulation with a 0.035-in guidewire. This strategy has sparked several debates. Compressing the axillary artery is the simplest and least expensive option to try first; internal compression may not even be necessary. Second, total protection from radiation is unlikely. We recommend taking the following precautions, which include using X-ray protective gloves and adjusting fluoroscopic settings (for example, using a lower flame rate, lower fluoroscopic dose, and shorter exposure times): (a) “Keep the rule of rotation not to exceed 180° (even more important with 4-Fr catheters), (b) keep a wire within the catheter to enhance the torque if needed, and (c) always watch your pressure while torquing, and when pressure curve is partially reduced.”

The documented techniques of unraveling a knotted and entrapped catheter include: (a) “gentle rotation of the catheter to the opposite direction, (b) advancement of a standard 0.035 J-wire or a super-stiff wire into the loop, (c) external fixation of the distal part of the catheter at the arm level both by putting circumferential pressure on the arm with the hands or with a (b) blood pressure (BP) cuff, (e) snare delivery from the ipsilateral femoral approach, (f) long sheath technique, (g) balloon aided retrieval technique and (h) sheathless guide catheter retrieval technique.”5

In particular, in the cases where no true knot is created, a simple, gentle rotation of the catheter to the opposite direction may be enough to unloop the catheter. If a tight knot is created, we may have to try to advance a wire. Any wire might be helpful in such a case. However, a first attempt with a standard Teflon coated 0.035 J-wire is usually performed, followed by a stiff hydrophilic wire (Glidewire, Terumo Europe) or even a Teflon-coated super-stiff (Amplatz Extra Stiff, Cook Medical) wire may of use to unravel the catheter knot. Wires smaller than 0.035″ are very unlikely that may be of any help.5

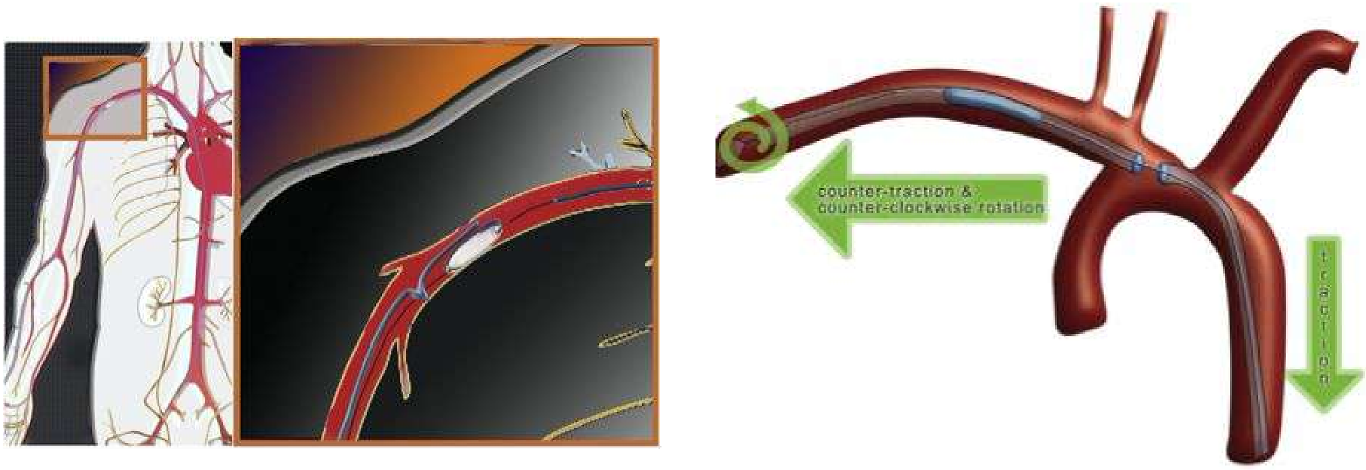


Figure 4. Schematic representation of the balloon-assisted catheter unknotting technique.[16-18]

If this maneuver fails, the doctor may try to fix the intravascular part of the catheter by applying an external force on the arm either with manual pressure or with a BP cuff. First, a typical 0.035 guidewire was introduced and gently manipulated counterclockwise. Extensive adipose tissue in the arm rendered manual external fixation of the catheter's distal end in the brachial area ineffective. Finally, the catheter was twisted proximally counterclockwise while a blood pressure cuff was securely fastened in the brachial region distal to the knot and inflated to 200 mmHg. With this maneuver, the knot was undone, the catheter was free to move, and it could be recovered. A snare must be used when applying external pressure to the arm is either impossible or ineffective.[5]

Another method for untangling a tangled catheter in the brachial artery was published by Waked et al. They advocated substituting a 6Fr sheath with a 45 cm 5Fr sheath and advancing it to the kink's base. The authors remark that they experienced difficulty advancing the catheter while contacting the left coronary artery using a 5Fr JL4 (Cordis Corporation) inserted through a 6Fr sheath. Upon fluoroscopy examination, a knotted catheter was found in the brachial region. Initial attempts to gently untangle the catheter were fruitless. The problem was fixed by exchanging the 6Fr 12 cm sheath for a 5Fr long sheath using the trapped JL4 as a guidewire. The trapped JL4 was gently retracted back while the long 5Fr sheath was advanced to the antecubital fossa under fluoroscopy; the resistance of the long sheath combined with the retraction force helped unravel the kink, and the catheter slid back into the sheath. To verify the openness of the brachial artery, the contrast was injected through the sheath.[5]

Layland et al. published a variation of the already described sandwich technique 32 to straighten a knotted guiding catheter in the axillary artery after the radial approach. In this case, catheter kinking occurred after successfully treating a coronary occlusion from a left-side approach. When retrieving an EBU3.5 GC catheter (Medtronic), the authors noticed that the catheter had become kinked in the axillary region. A super-stiff wire, gentle catheter rotation, and a conventional 0.035 guidewire failed. A 6Fr JR4 catheter was inserted through a TF approach to fix the issue. A Whisper MS wire (Abbott Vascular) was pushed through the JR4 and into the knotted EBU GC, bringing the JR4 within a few millimeters of the GC's distal tip. The distal end of the EBU catheter was then inflated with a 3.0 mm x 15 mm NC balloon (Abbott Vascular) that had been pushed through the JR4 over the MS wire. The kink was unraveled with the JR4/balloon combination, and the EBU catheter was withdrawn through the radial access after being retrieved into the ascending aorta with mild backward traction.[5]

Successful unique retrieval of a badly knotted catheter during TR access was achieved lately by Aminian et al. Sheathless Eaucath guide catheter use is safe and provides high success rates for complex TR procedures. In this case, the JR4 catheter had become significantly entangled in the brachial portion, with several loops and knots. The catheter could not be untangled by turning it counterclockwise, and no cables, not even hydrophilic-coated coronary wires, could pass through the tangled area. Therefore, it was decided to try retrieving the tangled catheter percutaneously via the original artery access using a sheathless guide catheter. To begin, the proximal end of a 5Fr diagnostic JR4 catheter was snipped off with a scalpel.

Second, a 7.5 Fr power backup sheathless guide catheter (Asahi) with a 100 cm length was employed, and its proximal end was trimmed by 60 cm with scissors. The exterior length of the JR4 catheter was 50 cm, but the knotted portion could only be removed around 10 cm below the elbow. To successfully retrieve the JR4 catheter, they determined that a residual length of 40cm was necessary for the sheathless guide catheter. A 7.5 Fr sheathless guide catheter was exchanged for the sheath of the 5Fr JR4 catheter. However, the 0.35 mm standard wire was left inside. The proximal end of the JR4 catheter, maintained firmly in place by the second operator, was then seen by gradually advancing the guide catheter. Under fluoroscopy, the guide catheter was advanced until it was adjacent to the loop; at that point, the diagnostic catheter's knot was loosened, and the diagnostic catheter slid easily into the larger guide catheter. After removing all catheters, an ultrasound of the forearm vasculature the next day confirmed the presence of a patent radial artery and the absence of any vascular complications.[5]

It is crucial to grasp the proximal tip of the trapped catheter as the guide catheter is advanced over it. Due to the decreased length of the catheter's exterior portion at greater artery depths, this technique cannot retrieve a knotted catheter. The removal of the proximal connector prevents the injection of contrast fluid during the process, which is the principal drawback of this method. However, fluoroscopic guidance is typically indispensable during retrieval procedures. "Since the dilatator of the catheter had to be removed, there is also the risk of injuring the radial artery during the replacement of the radial sheath for the catheter".[5]

These methods are routinely employed in endovascular practice, and the corresponding instruments are standard issues in the field.

4. Conclusion

Although it happens infrequently, a knotted catheter can become entrapped. There are a variety of approaches that can be taken to deal with this difficulty. Our cases show the value of taking things slowly. Extreme caution must be exercised to prevent further damage in the event of severe vascular spasms. We used a snare to snag the catheter's tip and untied the loop's knot. This prevented the need for unscheduled surgical intervention.

5. Declarations

5.1. Ethics Approval and Consent to participate
This study was approved by local Institutional Review Board, and all participants have provided written informed consent prior to involvement in the study.

5.2. Consent for publication
Not applicable.

5.3. Availability of data and materials
Data used in our study were presented in the main text.

5.4. Competing interests
Not applicable.

5.5. Funding source
Not applicable.

5.6. Authors contributions
Idea/ concept: NN, BS. Design: NN, BS. Control/ supervision: BS, IP, NK, MA. Literature search: NN, BS, MA. Data extraction: NN, BS, MA. Statistical analysis: NN, BS. Results interpretation: NN, BS. Critical review/ discussion: NK, IP, MA, BS. Writing the article: NN, BS. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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