Managing the Complications of Long-Term Tunneled Dialysis Catheters

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ABSTRACT

The Kidney Disease Outcomes and Quality Initiative (K/DOQI) guidelines call for a significant increase in the use of natural vein fistulas. Long-term tunneled dialysis catheters (LTTDCs) will have an important role in facilitating the maturation of natural vein fistulas. LTTDCs also functions as the access of last resort in patients who refuse or have exhausted other forms of permanent vascular access. This article, which is based on the authors' experience as interventional nephrologists, discusses factors influencing catheter function. In addition, the article reviews common complications associated with dialysis catheter insertion, including immediate, short-term, and long-term complications. The topics reviewed include stenoses, thrombus formation, fibrin sheath formation, infections, and vascular ingrowth. Suggestions for management are also discussed.

Vascular access for hemodialysis (HD) remains an important issue in managing patients with end-stage renal disease (ESRD). Although it is widely accepted that arteriovenous fistulas (AVFs) should be the mainstay of vascular access for HD, this goal is not always possible or practical. The Kidney Disease Outcomes and Quality Initiative (K/DOQI) practice guidelines mandate standards for dialysis access and maintenance (1). The current K/DOQI guidelines recommend that 50% of all new accesses for HD be natural vein fistulas, with a goal prevalence of 40% fistulas throughout the dialysis population of the United States (1). To achieve this goal, long-term tunneled dialysis catheters (LTTDCs) remain an integral tool both as a bridge for fistula maturation and as the sole venous access in a select population.

To illustrate this, data from one nephrology practice, the Arizona Kidney Disease and Hypertension Center (AKDHC), will be reviewed. This practice of 20 nephrologists has a population of approximately 1200 ESRD patients in more than 20 dialysis units. In 1998, in an effort to improve patient care, a decision was made to centralize the creation and care of vascular access. To this end, an active surveillance program was initiated, followed by the creation of an interventional nephrology laboratory staffed by two interventional nephrologists, including one of the authors (D.A.S.). The laboratory performs approximately 400–500 catheter-related procedures per year. Table 1 illustrates the effect of this program on access prevalence over the last 4 years.

The incidence of grafts has decreased sharply, while the incidence of both fistulas and catheters has increased. About one-quarter of all patients with a catheter have a fistula that is maturing. When this is taken into account, the prevalence of fistulas becomes 49%. While the total percentage of the population with catheters increased from 16% to 27%, this increase is temporary and will decrease to 19% when the associated fistulas are mature.

In reviewing these statistics, it is clear that despite aggressive, centralized management of vascular access, significant use of catheters will still be necessary, either as the sole access or as a temporary access during maturation of a fistula. Therefore understanding the management of catheters and their complications becomes essential to the success of a vascular access program. This article reviews this subject from a practical perspective; no exhaustive review of the field will be made. However, an effort will be made to concentrate on tips to help ensure adequate catheter flow as well as management of short- and long-term complications related to the use of LTTDCs.

For practical purposes, it may be easier to divide the subject into 1) catheter function, 2) immediate or short-term postinsertion complications, 3) long-term complications, and 4) infection.

Catheter Function

Long-term tunneled dialysis catheters can be cuffed or uncuffed, and can be tunneled antegrade (skin to insertion site) or retrograde (insertion site to skin).

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TABLE 1. AKDHC access prevalence

	1998	2002
Grafts	49%	30%
Fistulas	34%	42%
HD catheters	16%	27%
Catheters with fistulas		7%
Catheters with grafts		1%

As the basic principles of insertion and management for all types of catheters vary only in the order of their insertion steps, they will be considered together (2).

The first step in ensuring catheter function is an appropriate set of expectations by the nephrologist. If a blood flow (BF) of 300 ml/min is acceptable, then most catheters on the market today can achieve this goal, provided they are placed correctly. However, if a BF of ≥400 ml/min is desired, then meticulous attention to every detail of insertion and management is required. First, arterial pressure monitoring cannot be utilized. The advisability of utilizing arterial pressure monitoring in the venous system is a moot point. Whatever the individual's opinion on this subject, the fact remains that negative pressure created by the blood pump will preclude the achievement of a BF that is greater than 300–350 ml/min on a sustained basis. This is true for all the commercially available arterial pressure monitors on the market today.

To achieve a sustained BF of ≥400 ml/min, a ≥16 Fr. catheter will be required. In the authors experience, even if a ≥16 Fr. catheter is used, the two most common problems limiting catheter flow relate to catheter tip position and kinks in the tunnel (3).

In the authors' experience, the tips of the arterial as well as the venous lumen need to be placed within the right atrium to achieve a BF of ≥400 ml/min on a reproducible basis (Fig. 1) (3,4). Furthermore, cuffed catheters, by their nature, are secured at the point where the cuff is fibrosed to the surrounding tissue. When an obese individual or a large-breasted female sits erect, the weight of the chest wall pulls the catheter tips up and potentially out of the right atrium (5,6). This needs to be factored into the initial catheter tip placement, as illustrated in Fig. 2. In addition, in the femoral position one may need to use a 45 cm or 55 cm long catheter for best results.

The catheter lumen can be very easily compromised by kinks created during the tunneling process (Fig. 3) (3,7). To prevent this, the tunneler(s) should be bent into the shape of a C or U (Fig. 4) prior to starting the tunnel. This facilitates the creation of a smooth arc in the tunnel and avoids any constriction to the catheter lumen (Fig. 5).

FIG. 1. Proper catheter tip placement. Both tips of this catheter are placed into the right atrium to achieve maximal blood flow.

Immediate Complications

Complications related to the insertion process are familiar to most nephrologists from experience in inserting and managing central venous catheters of all types. They will not be dwelt upon and are listed in Table 2.

The biggest factor in managing these complications is awareness and prevention (8). Ultrasound guidance has been found to markedly reduce insertion complications and is recommended by the K/DOQI guidelines (1,8,9). In addition, the use of a 21-gauge micropuncture set further reduces the complications ensuing from inadvertent arterial and pleural puncture. Such sets are well known to interventional nephrologists and radiologists, but not to the general population of practicing nephrologists. They consist of a 21-gauge insertion needle and a set of graduated dilators (Fig. 6), allowing for the exchange and insertion of an 0.035 mm guide wire. This avoids the need to puncture the vessel with an 18-gauge needle.

Central vessel perforation (transection) is a potentially fatal complication that results from the large tissue dilator perforating the vessel wall during insertion (11). This is preventable by the meticulous practice of ensuring that the dilator moves smoothly over the guide wire during the insertion procedure. If this is not carefully attended to, a kink may occur in the guide wire, which allows the dilator to transect the wall of the central vessel rather than follow the wire down into the vessel lumen.

Long-Term Complications

The most common long-term complications associated with the use of LTTDCs are listed in Table 3. Most authors counsel the avoidance of the subclavian site for catheter insertion because of the high association of subclavian catheters with central vessel stenosis (12).

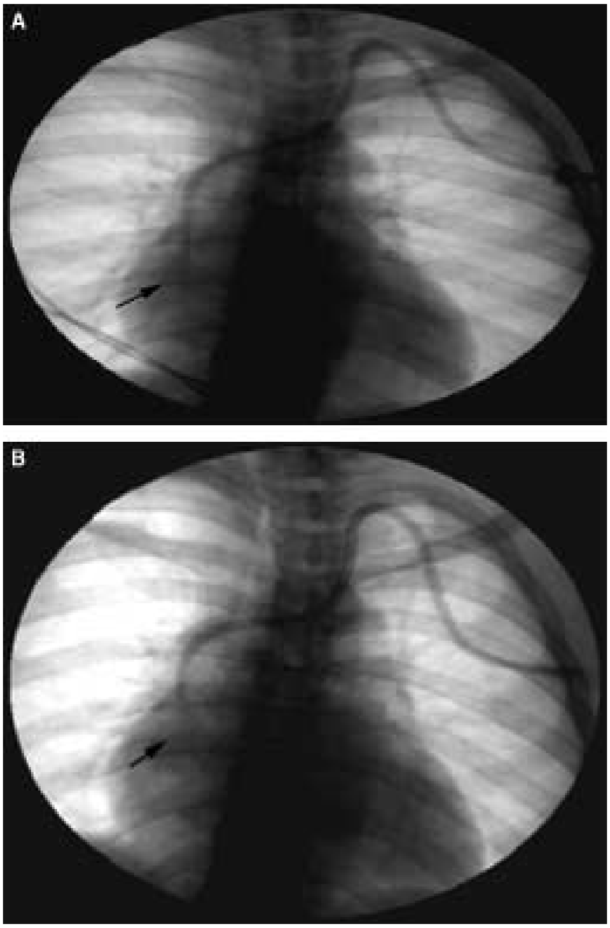


FIG. 2. Catheter tip movement in a cuffed catheter upon assuming the upright position. (A) The catheter tips of this cuffed catheter are placed just within the right atrium. However, when the patient sits up (B), the tips are pulled out of the atrium by the weight of the chest wall. (Radiograph courtesy of Gerald Beathard, MD.)

Indeed, the K/DOQI guidelines recommend the right internal jugular position for catheter placement (10). From the left internal jugular vein, the catheter must traverse curves at both the junction of the internal jugular vein with the subclavian vein as well as the bend where the left innominate vein turns to meet the right innominate vein (Fig. 7) in order to reach the right atrium. Since venous irritation at these sites may lead to stenosis, most authorities recommend that the left internal jugular vein be avoided as a site for catheter implantation (13).

This is confirmed by the authors' practice of injecting contrast upon the removal of all LTTDCs that have been in place ≥30 days. All 167 catheter removals performed by one of the authors (D.A.S.) between January 2001 and February 2, 2002, whether for discontinuation of catheter-based dialysis or replacement for infection or nonfunction, were reviewed. In 15 cases, no injection was performed. Reasons for not injecting included diabetics who recovered renal function but maintained a serum creatinine greater than 2.0 (four cases), severe tract infection (two cases), or no reason was given (nine cases). Of the catheters injected, there were only four subclavian

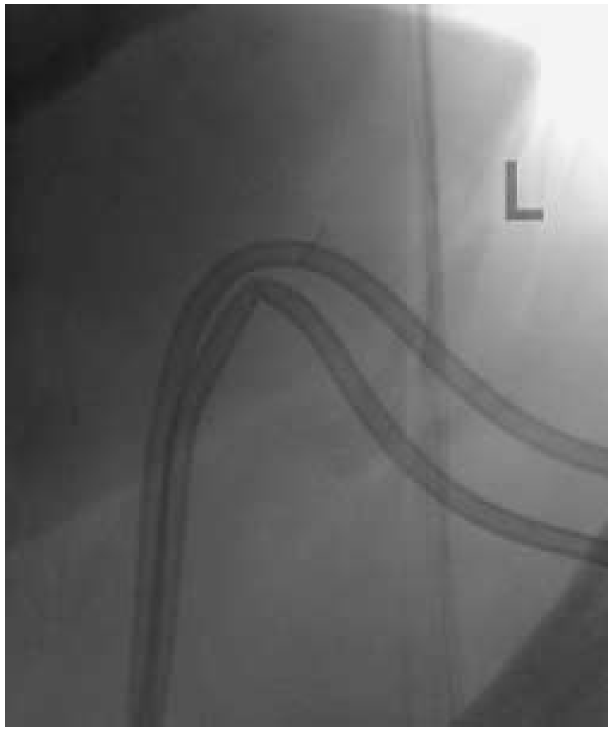


FIG. 3. Restriction of flow from a kink in the tunnel in the neck. Note the kink in the tunneled portion of this catheter (arrow) where the tunnel was not curved correctly.

catheters. There were 20 left internal jugular and 130 right internal jugular catheters. The incidence of stenosis was 40% (8/20) for left internal jugular catheters and 27% for right internal jugular catheters.

Several conclusions can be drawn from these data. First, the overall incidence of central vessel stenosis will vary in any series based on the ratio of subclavian, internal jugular, left-sided, and right-sided catheters. Second, the left internal jugular vein is associated with a much higher incidence of stenosis than the right internal jugular vein (12,14). Third, the incidence of central vessel stenosis with right internal jugular catheters is consequential.

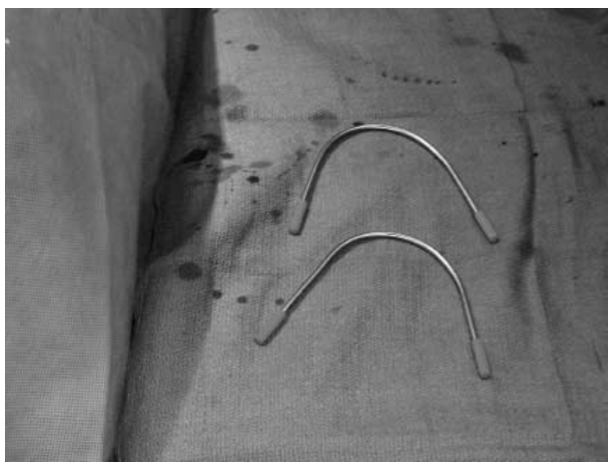


FIG. 4. Proper tunneler shape. Note how these tunnelers have been curved to facilitate the creation of a smooth lumen in the tunnel.

FIG. 5. Proper shape of the catheter in the tunnel. Note the smooth curvilinear shape of the catheter exit tubes in the tunnel (arrow).

TABLE 2. Short-term complications

Pneumothorax/hemothorax/hemomediastinum
Dissection/occlusion of the carotid artery
Central vessel perforation

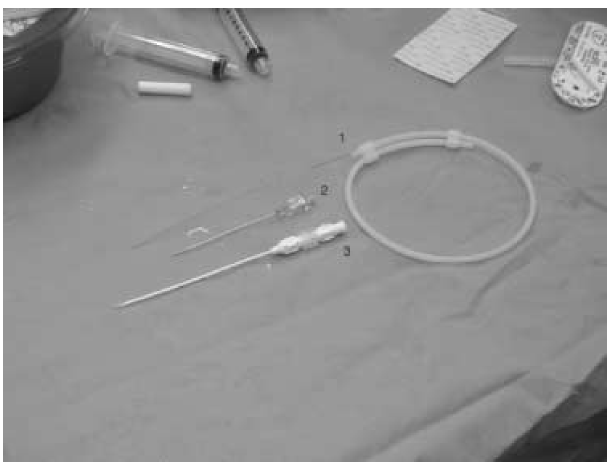


FIG. 6. Micropuncture set. The micropuncture insertion set consists of a 21-gauge micropuncture needle (2), a 0.018 mm metal wire with a flexible tip (1), and a set of 3 Fr. (or 4 Fr.) and 5 Fr. dilators which fit into each other. The outer 5 Fr. dilator will accommodate the 0.035 mm wire, which is needed for the catheter insertion.

TABLE 3. Long-term complications

Stenoses in central vessels
Central thrombus formation
Fibrin sheath formation
Catheter-related infections
Permanent vascular ingrowth

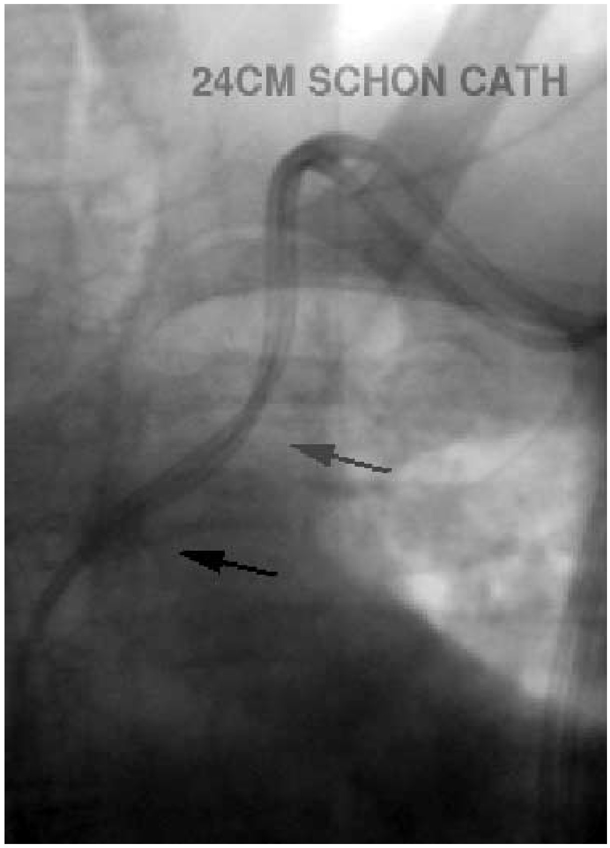


FIG. 7. Left internal jugular catheter placement. Note that from the left internal jugular vein, the catheter drapes itself around the subclavian vein and also abuts the innominate vein, potentially irritating both (arrows).

The management of central stenosis is evolving. When present on the side of a peripheral access (fistula or graft), significant arm edema may ensue (Fig. 8). Therefore every effort should be made to avoid catheter placement on the same side as a developing fistula or graft. When a stenosis is found, it should be dilated with a balloon at least as large as the contiguous uninvolved vein (15) (Fig. 9). Unfortunately central vessel lesions are often recurrent (15–17). While the use of flexible subclavian stents (Fig. 10) is growing in popularity, the long-term outcome with these appliances is still a subject of debate (18,19).

Fibrin Sheaths

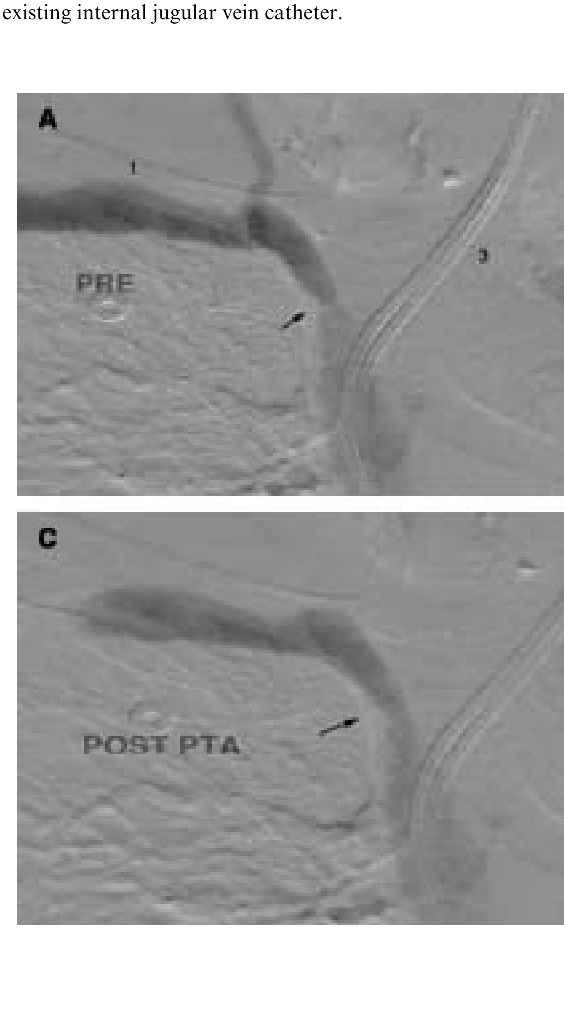
Fibrin sheaths are also very common and have been reported in up to 50% of catheters with dysfunction (20). This is confirmed by the authors' experience. In the analysis reported above, injections were performed at the time of removal of 152 catheters. Of these, 57 (38%) demonstrated fibrin sheaths.

Over time, fibrin sheaths may become quite organized (21–23). They can be short or quite long (Fig. 11) and appear to originate at the site of insertion or the subcutaneous cuff and migrate down the length of the catheter (Fig. 12). Eventually they cover the intake and outflow holes and result in catheter dysfunction. If not recognized at the time of an exchange procedure for catheter dysfunction, the new catheter may be inserted into the existing sheath, resulting in no improvement in flow (24).

Fig. 8. Arm swelling from central stenosis. Note the swollen arm after placement of a new access in an arm on the same side as an existing internal jugular vein catheter.

The management of fibrin sheaths varies and is summarized in Table 4. In an effort to preserve catheter function, various regimens of lytic enzyme infusions have been developed (25,26). The most accepted involve the use of a continuous infusion of lytic enzymes over 2–4 hours. They have several drawbacks. First, the enzymes can be very expensive (a 50 mg vial of tissue plasminogen activator [TPA] is more than $1000) and the infusion requires significant dialysis staff time. The infusion also exposes the patient to systemic doses of lytic enzymes with potential complications (27). In the authors' experience, a much less expensive, risk-free, and user-friendly variant is to instill a TPA and heparin solution into the catheter overnight or until the next dialysis as follows: 1 ml (1 mg) of TPA + 0.4 ml of 5000 U/ml heparin (2000 U) + saline flush to the volume of the catheter lumen. In the authors' experience, if this does not improve the catheter performance, then a more invasive approach is warranted. While simple and attractive, this approach has never been systematically studied.

Fibrin sheath stripping is technically satisfying to many interventional radiologists. This is performed by looping the catheter exterior with a snare and stripping off the sheath (28). However, this technique is invasive, requiring a femoral puncture. It is also expensive because of the cost of the interventional room and snare. A more



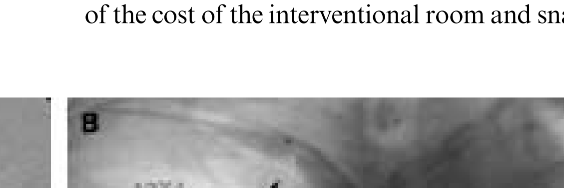


Fig. 9. Angioplasty of a central stenosis. Right innominate stenosis (A) before (arrow), (B) during, and after (C) TPA.

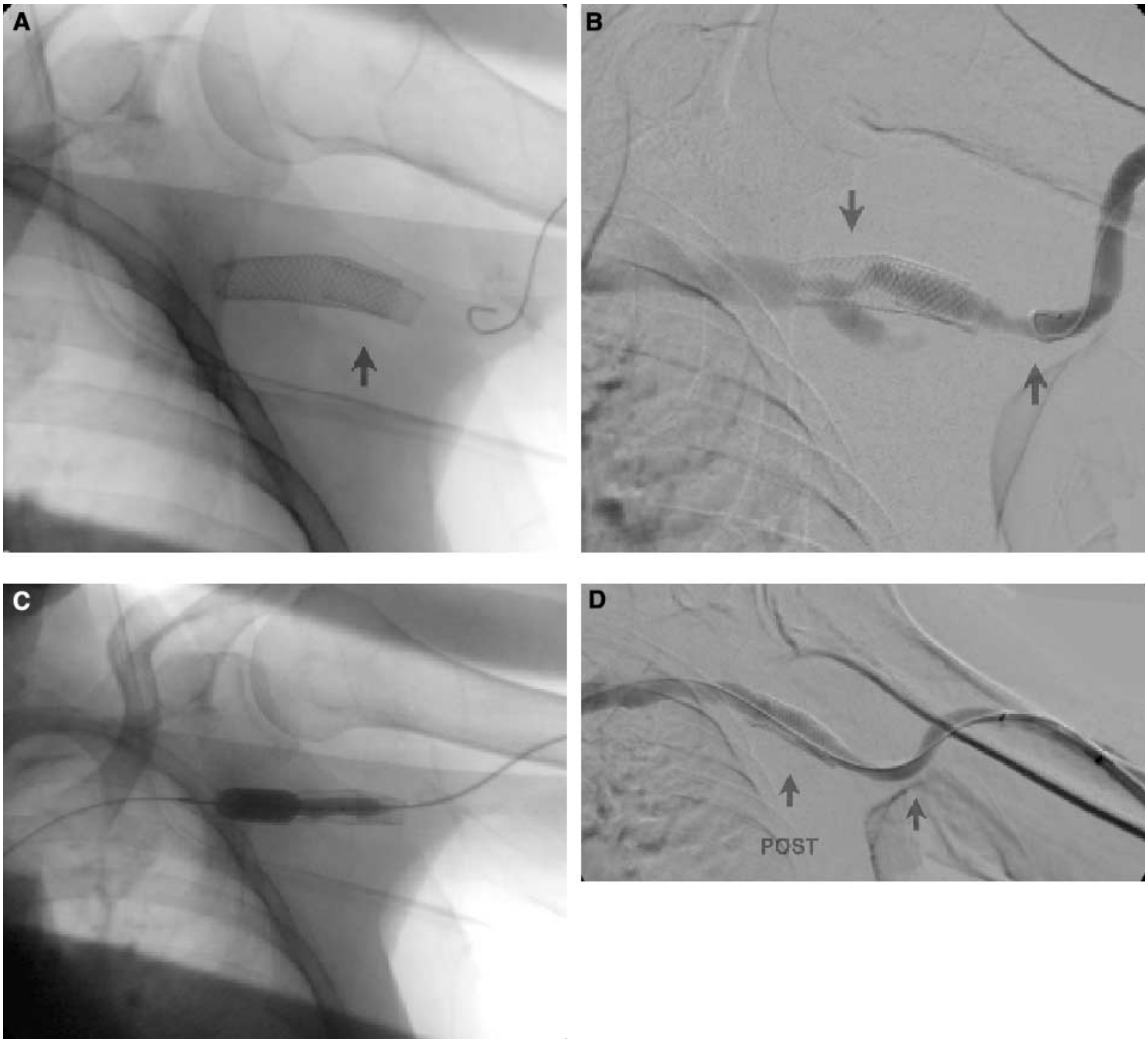


FIG. 10. Central stent. Note that in this axillary vein is (A) a stent (arrow) placed inside a stent because of recurrent stenosis. (B) Demonstrates recurrent stenosis within the two stents. The right arrow is at the venous anastomosis of an upper arm graft. (C) A 12 mm high-pressure balloon is used to dilate the stenosis. (D) Demonstrates the post-PTA result.

definitive procedure, perhaps, is to remove the catheter over a wire, disrupt the sheath with a balloon catheter, and then place a new dialysis catheter in the same vessel without a new veinpuncture (29).

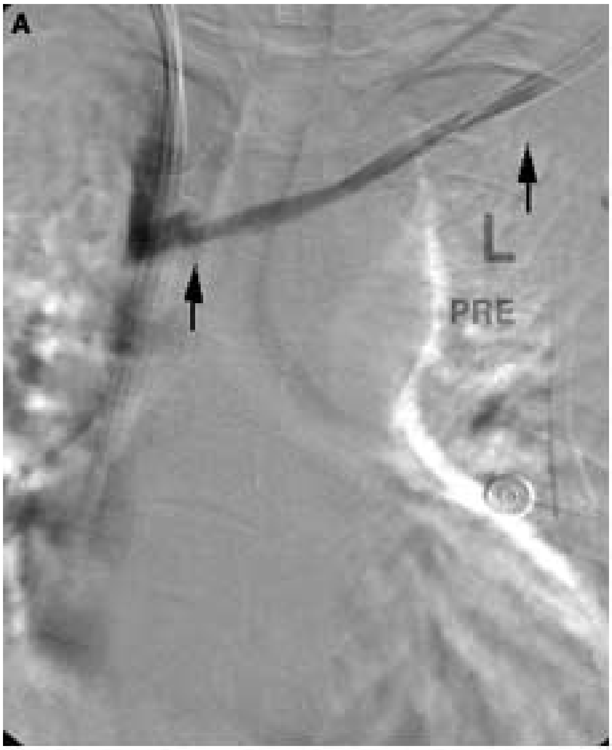
Thrombus formation is a less commonly recognized complication. It may occur on the right atrial wall or on a vessel wall (30). Occasionally it may completely occlude a vessel (Fig. 13). The advisability of anticoagulation in such cases to prevent pulmonary emboli and clot propagation has not been studied.

A potentially more serious complication is that of tissue ingrowth into the catheter itself. The authors have seen two cases, and been informed of two additional cases, in which tissue ingrowth into the catheter material has entrapped the catheter on the endothelial surface of the vessel. The catheter could not be removed by a cut down to the internal jugular vein and would have required a thoracotomy for removal. In each case it was elected to close the severed lumen of the catheter remaining in the patient with suture and leave the catheter within the vessel. One patient has been under the authors' care for 3 years since this was recognized and has had no further sequelae. The management of this complication has not been defined.

Infection

Infection is a potentially life-threatening complication. Exit site infections are common and are usually treatable with antibiotics orally or after dialysis (31). Tract infections are much more serious, especially when a Dacron cuff is present. They will not be cleared without removal of the catheter and the catheter should definitely not be placed back in the same site until the infection is cleared (Fig. 14) (32,33).

Catheter-related bacteremia requires careful attention. If the patient is clinically septic, the catheter should be



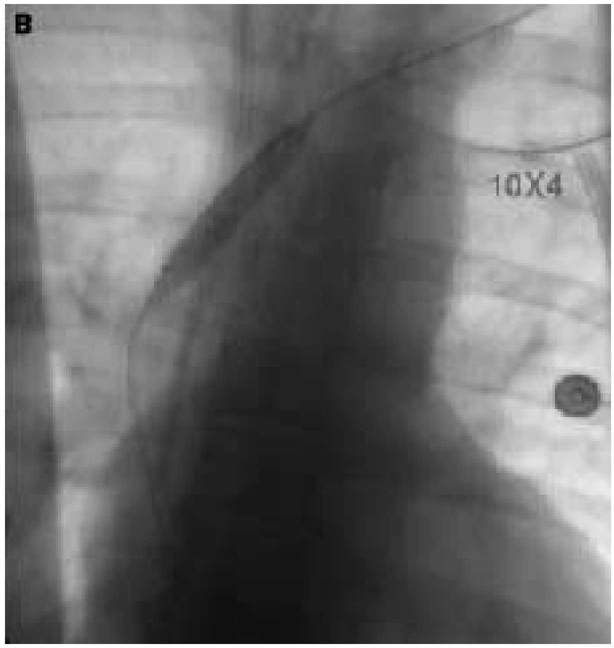


FIG. 11. Fibrin sheath. (A) An injection through the end of a catheter during removal (right arrow) demonstrates a sheath extending to the junction with the right innominate vein (left arrow). (B) The sheath is disrupted with a 10 mm balloon. (C) Normal subclavian/innominate system after PTA.

removed immediately. As with a severe tract infection, appropriate cultures should be obtained and the bloodstream cleared for 48–72 hours prior to reinserting another catheter (31). If not promptly addressed, catheter-related infections can lead to subacute bacterial endocarditis, osteomyelitis, and epidural abscess (32–35).

FIG. 12. Fibrin sheath. Fibrin sheath illustrated in Fig. 11 starting at the cuff of this LTTDC during removal.

FIG. 14. Tract or tunnel infection. Note the red and raised area in the tunnel above the exit sites.

TABLE 4. Management of fibrin sheaths

Overnight instillation of lytic enzymes
4-hour infusion of lytic enzymes
Fibrin sheath stripping
Mechanical disruption of the sheath at the time of catheter exchange

FIG. 13. Thrombus formation in the right subclavian vein. (1) Demonstrates the right subclavian vein. The offending right internal jugular catheter is at (2). The innominate-superior vena cava junction is at (3). (Courtesy of Ted Saad, MD.)

It is well documented that the bloodstream cannot be effectively cleared without the removal of the foreign body because the infected biofilm found at the catheter tip (36,37) cannot be sterilized with antibiotics. However, several authors have demonstrated that antibiotic therapy coupled with catheter exchange over a guide wire, with a new tunnel when appropriate, obviates the need for a new veinpuncture in more than 80% of patients (33,37,38).

In conclusion, it is clear that vascular access management in the United States is far from ideal. In an attempt to improve this aspect of ESRD care, the K/DOQI guidelines were developed. It is the authors' experience that the 40% fistula prevalence goal set forth in the K/DOQI guidelines is very achievable. However, catheter use may well increase before it decreases. To the extent that this statement is valid, an understanding of the principles of catheter-related complications and their management will be essential to the practicing nephrologist.

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