Unconventional Venous Access: Percutaneous Translumbar and Transhepatic Venous Access for Hemodialysis

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8.1 Introduction

The National Kidney Foundation Kidney Disease Outcomes Quality Initiative™ (NKF KDOQI™) Clinical Practice Guidelines on chronic kidney disease (CKD) estimate that CKD affects more than 50 million people worldwide and more than one million of these patients are receiving hemodialysis [1]. In the USA alone, more than 382,000 patients were receiving hemodialysis for ESRD through 2008 [2]. Maintenance of functional venous access for hemodialysis often determines the survival of patients with end-stage renal disease [3]. Despite ongoing initiatives to reduce central venous catheter use for hemodialysis such as KDOQI and the CMS Fistula First program, the use of catheters has remained 17–18 % in prevalent hemodialysis patients since 2003 [2]. Published data support the use of the internal jugular veins as the initial vascular access site for placement of central venous catheters for hemodialysis [4, 5]. Prolonged central venous catheterization commonly results in endoluminal thrombosis, stenosis, or occlusion. Eventual exhaustion of venous access options often occurs prior to the availability of a surgical vascular access or suitable renal transplant donor. In patients with chronic total occlusion of the jugular, subclavian, and femoral veins, alternative unconventional access sites must be explored. This includes use of the inferior vena cava (IVC) via the translumbar and transhepatic approaches. There are only a small number of studies to date reporting on translumbar and transhepatic catheters for hemodialysis [3, 6–13]. Nonetheless, familiarity with the patient selection and technical considerations of percutaneous translumbar and transhepatic venous access for hemodialysis and the management of related complications is requisite for any practitioner who cares for the catheter-dependent hemodialysis patient.

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8.2 Catheter-Based Hemodialysis

Catheter hemodialysis presents a conundrum—catheters provide access that is immediately available, but complications of catheter use remain quite high [14]. As per recommendations of the KDOQI, the ideal hemodialysis access permits a flow rate to the dialyzer adequate for the dialysis prescription, has a long-use life, and has a low rate of complications (e.g., infection, thrombosis, stenosis, aneurysm, and distal limb ischemia) [15]. Undoubtedly, a surgically created arteriovenous fistula provides the most optimal and durable fulfillment of these criteria. Although fistulae have been shown to have the lowest rate of thrombosis and require the fewest interventions [16], an arteriovenous graft is often requisite for patients in whom a fistula cannot be created because of anatomic or technical limitations. Catheter hemodialysis remains the least desirable and often the last option for patients with end-stage renal disease. In an effort to reduce morbidity in the hemodialysis population, KDOQI has proposed a limitation of less than 10 % of patients using catheters as a primary mode of access [15].

Hemodialysis catheters can be defined based on design, intent, and duration of use. Acute or short-term catheters (three to five dialysis sessions within 1 week) are typically non-cuffed and placed such that the catheter tips reside in the superior vena cava. On the contrary, long-term catheter systems—those intended for vascular access for hemodialysis over weeks to months—are cuffed catheters and are frequently tunneled in the subcutaneous tissues to permit catheter retention and minimize infectious complications. Such catheters should have their tips in the right atrium to permit optimal flow. Contemporary hemodialysis catheters are usually dual lumen with a tip design that is either stepped (i.e., the arterial and venous tips are staggered by 1–2 cm) or split

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so that the tips are not next to each other [15]. Newer designs such as the Tal Palindrome catheter (Covidien, Mansfield, Massachusetts) have a symmetric tip design that incorporates a spiral separator that allows reversal of the arterial and venous lines during hemodialysis with reduced risk of recirculation.

Tunneled cuffed hemodialysis catheters should be placed in a vein that is easily accessible using sonographic and fluoroscopic guidance. The internal jugular veins are generally favored as the initial choice for central venous access [5]. The right internal jugular vein is preferable to the left because this site offers a more direct route to the right atrium. If both of the internal jugular veins become occluded, alternative access sites must be explored. Choices include the external jugular, subclavian, and femoral veins. Unfortunately, the high-rate of venous thrombosis and occlusion associated with prolonged central venous catheter use results in the exhaustion of even these unconventional access sites. Elaborate vascular surgical procedures have evolved to bypass stenoses with the interposition of prosthetic graft material to create a patent arteriovenous circuit that supports hemodialysis, but such surgical intervention may not always be acceptable or feasible [17]. Unconventional approaches to central venous access may be entertained only when all other surgical and endovascular options have been exhausted. Translumbar and transhepatic cannulation of the inferior vena cava, the former first described over 20 years ago, reflect two such unconventional approaches into a central vein that have been described in the literature [6–13]. To be sure, these sites require considerable technical expertise for catheter placement, and maintenance of catheters at these sites may be somewhat more problematic. Transhepatic guidance of translumbar hemodialysis catheter placement has been described in the setting of chronic infrarenal inferior vena cava occlusion [3], but this technique is technically challenging and remains an infrequent method of central venous access. Percutaneous puncture of the renal vein via the transrenal approach was first described by Murthy et al. [18], but widespread use of this technique remains limited due to a potentially high risk of bleeding and limited precedent in the literature.

8.3 Patient Selection

8.3.1 Indications

For those patients in whom translumbar or transhepatic cannulation of the inferior vena cava is contemplated, most options for surgical vascular access have been exhausted or have become impractical due to thrombosis or chronic total occlusion of the central veins. Translumbar or transhepatic placement of inferior vena cava catheters has been accepted as the last useful and reliable alternative in patients who require long-term hemodialysis but have exhausted all other conventional access sites.

8.3.2 Contraindications

Similar to more conventional sites of central venous access, there are no absolute contraindications to placement of a tunneled cuffed hemodialysis catheter into the central veins via the translumbar or transhepatic routes. When more permanent surgical access options exist (e.g., AV fistulae and grafts), the use of catheters as a primary mode of hemodialysis should be discouraged. Most interventionalists avoid placement in patients with uncorrectable coagulopathy, active infection, or proven bacteremia. In our institution, blood cultures must be negative for at least 24 h prior to considering placement of a tunneled hemodialysis catheter. Coagulopathy is a relative contraindication to placement of a translumbar or transhepatic catheter, and in those patients with a bleeding diathesis or those taking systemic anticoagulants should ideally be corrected prior to catheter insertion. Platelet replacement or the administration of fresh frozen plasma can be performed if necessary. Available data suggest an international normalized ratio (INR) of less than 1.5, and a platelet count greater than 50,000/mm^3 carries less risk of bleeding during and after tunneled central venous catheter placement [19].

Morbid obesity may be considered a relative contraindication to translumbar placement of tunneled hemodialysis catheters. Several studies have suggested an increased risk of catheter migration out of the inferior vena cava and into the subcutaneous soft tissues or retroperitoneum in these patients [6, 8, 9]. Patient selection criteria based on obesity are very subjective, although truncal obesity is considered a more definite risk factor for translumbar catheter migration [8]. If a translumbar catheter is placed in a child, the performing physician must be aware that interval growth may lead to displacement of the catheter tip to an extravascular location [20]. Plain radiographs may be used to monitor for appropriate positioning of the catheter tip over time.

Infrarenal caval occlusion may result in technical failure of the translumbar approach and should be considered a relative contraindication to translumbar cannulation of the inferior vena cava. In these patients, a transhepatic route may provide their final percutaneous access site, although it may be complicated by a high rate of catheter thrombosis (0.18–0.24 per 100 catheter days) [11, 13] and migration (14–37.4 %) [11–13]. Ascites is considered a relative contraindication to transhepatic catheter placement. Pre-procedure paracentesis may lessen the bleeding risk of the transhepatic route, however.

8.4 Technique

8.4.1 Translumbar IVC Catheter Placement

Easily accessed by direct percutaneous puncture, the inferior vena cava provides a durable conduit for central venous access. Percutaneous puncture of the inferior vena cava with subcutaneous tunneling of a catheter was first described by Kenney et al. [21] in 1985 as an alternative means of access to the central venous circulation for long-term parenteral nutrition. The safety and efficacy of larger, long-term translumbar hemodialysis catheters (14 French) was first demonstrated by Lund et al. [6] several years later. This group detailed insertion of 17 double-lumen hemodialysis catheters in 12 adult patients. Cumulative patency was 52 % at 6 months and 17 % at 12 months [6]. Despite this early data, there remain only a small number of studies to date reporting on translumbar placement of hemodialysis catheters.

Placement of translumbar hemodialysis catheters has been described in both the pediatric and adult patient populations [6–10, 22]. The technique for translumbar hemodialysis catheter placement is identical for pediatric and adult patients, although general anesthesia is used in the pediatric population at our institution. At present, there is no support in the literature for prophylactic antibiotic administration prior to placement of tunneled hemodialysis catheters. This is supported by the Centers for Disease Control in a type I-A recommendation published in 2002 [23]. Nonetheless, at many health-care centers patients still receive intravenous antibiotic prophylaxis, usually with a first-generation cephalosporin such as cefazolin.

Insertion technique may vary depending on the presence of preexisting iliofemoral thrombosis or obstruction. When the iliofemoral veins are patent but conditions such as a local cutaneous infection or systemic neutropenia necessitate an alternative approach to tunneled femoral venous access, transfemoral placement of a pigtail catheter or guidewire into the inferior vena cava has significant utility. The presence of an intra-caval catheter or guidewire facilitates subsequent direct inferior vena cava puncture, while minimizing potential morbidity from errant needle passes. In such instances, the patient is brought to the angiography suite and initially placed in the supine position. Ultrasonography is used to confirm patency of one or both common femoral veins. A suitable groin site is then prepped and draped in the usual sterile fashion. Buffered 1 % lidocaine is infiltrated to provide local analgesia prior to percutaneous puncture of the common femoral vein. Using sonographic guidance, the right or left common femoral vein is punctured with a 21-gauge needle. A 0.018-in. guidewire is passed through the access needle into the common femoral vein. Over the guidewire, the needle is exchanged for a coaxial microintroducer sheath, which facilitates exchange of the 0.018-in. guidewire for a larger 0.035-in. working wire. A 4- or 5-French vascular sheath is then advanced over the guidewire into the accessed common femoral vein. A guidewire or pigtail flush catheter is advanced through the transfemoral access into the inferior vena cava to act as the fluoroscopic marker for direct percutaneous puncture of the inferior vena cava. A cavogram should be performed if the patency of the inferior vena cava has not been pre-procedurally evaluated with cross-sectional imaging. [20] Once the guidewire or catheter is secured in place, the patient is placed in the prone position for puncture of the inferior vena cava.

Percutaneous cannulation of the inferior vena cava is performed from a right paramedian approach, irrespective of the presence or absence of a transfemoral inferior vena cava catheter or guidewire. The right flank and anterolateral abdomen are prepped and draped in the usual sterile fashion. Local anesthesia is administered immediately superior to the right iliac crest, approximately 8–10 cm lateral to the midline. Using fluoroscopic guidance, a 21-gauge, 15-cm-long needle is used to puncture the inferior vena cava by targeting the previously placed guidewire or pigtail catheter. If there is known obstruction of both iliofemoral veins and a transfemoral fluoroscopic marker cannot be placed, the inferior vena cava is directly punctured using bony fluoroscopic landmarks for guidance. In this setting, the needle is advanced craniomedially, targeting the anterolateral margin of the L2–L3 vertebral bodies so as to puncture the inferior vena cava just below the renal veins. Intraluminal position is confirmed by free aspiration of blood through the needle. If the needle appears to be in the location of the inferior vena cava but blood cannot be aspirated, gentle administration of contrast media can help confirm intravascular needle position. Contrast administration also excludes unintended entry into the renal vein and thereby avoids the potential complications of renal vein thrombosis and catheter dysfunction [8]. A 0.018-in. platinum-tipped mandril guidewire is then introduced through the access needle and advanced to the inferior cavoatrial junction or right atrium. The needle is exchanged for a coaxial transitional sheath (Accustick system, Boston Scientific, Natick, Massachusetts), which permits replacement of the 0.018-in. guidewire with a 0.035-in. guidewire. Intravascular catheter length is measured and selected in standard fashion. The selected dual-lumen, cuffed hemodialysis catheter is then tunneled through the subcutaneous tissues of the right flank and brought out at the initial access site, keeping the retention cuff approximately 2 cm from the catheter exit site. The tunnel should form a gentle angle with respect to the venotomy site, and the catheter exit site should be located as far laterally as possible to facilitate improved catheter care and patient comfort [20]. Creating a tunnel that is too long can make future catheter manipulations through the same tunnel difficult, if not impossible. Attention is once again directed toward the initial percutaneous access into the inferior vena cava. The transitional dilator is exchanged over the guidewire for an appropriately sized peel-away sheath. Longer introducer sheaths may be necessary for larger patients. Great care should be taken to avoid kinking the guidewire as it can hinder intravascular placement of the introducer sheath and increase the risk of retroperitoneal bleeding. Once the peel-away sheath is placed, the inner dilator and guidewire are removed, and the catheter is inserted through the sheath in standard fashion. Completion radiographs centered on the right hemidiaphragm should demonstrate the catheter tip in the right atrium. The catheter is sutured in place, and the initial puncture site is closed using interrupted sutures or Steri-Strips (3 M, St. Paul, Minnesota). Both lumens of the catheter should be heparinized to minimize the risk of catheter thrombosis.

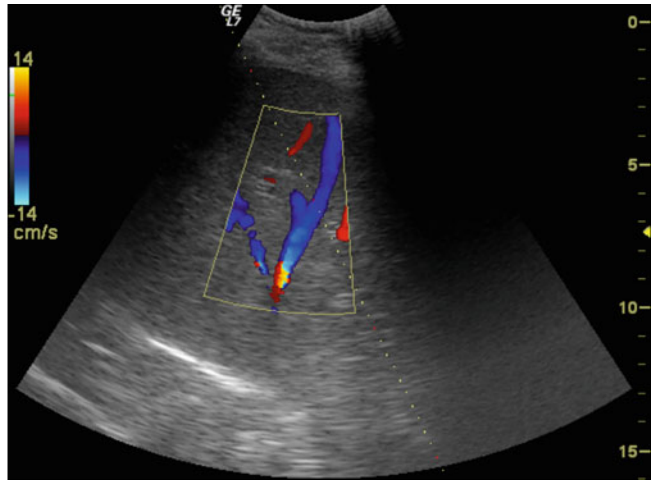


Fig. 8.1 Pre-procedure transverse color Doppler image shows planned route of transhepatic puncture into the middle hepatic vein

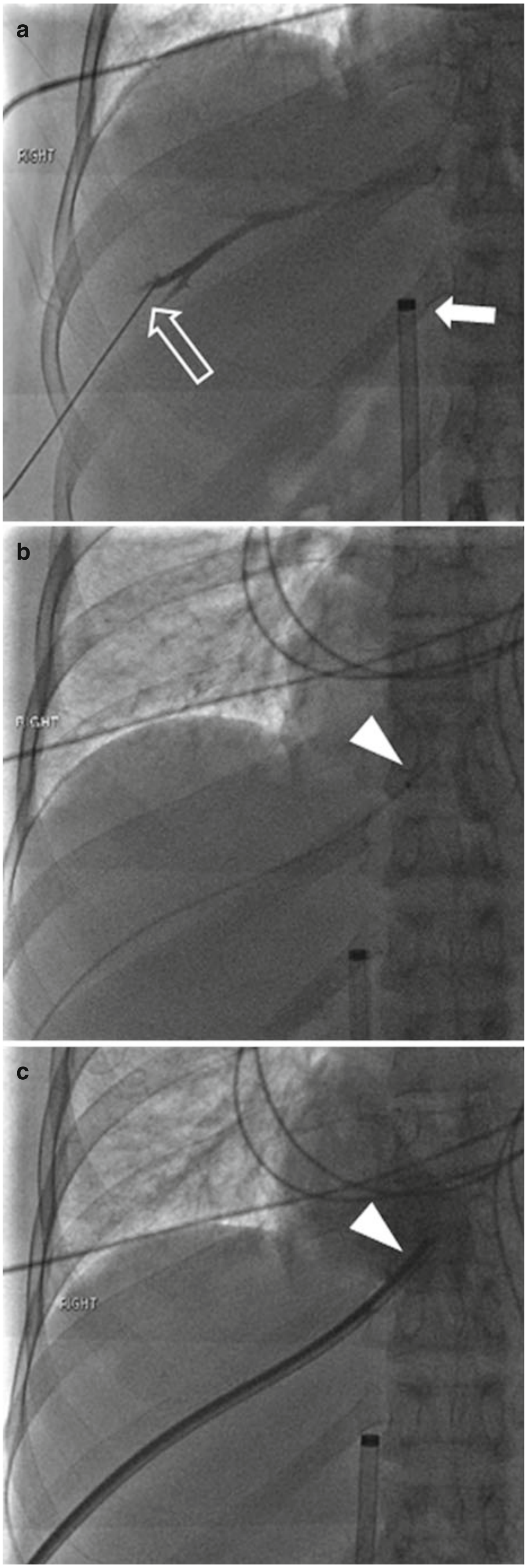
8.4.2 Transhepatic Catheter Placement

In some instances, occlusion of the infrarenal inferior vena cava may result in technical failure of the translumbar approach for hemodialysis catheter placement. Percutaneous transhepatic puncture of a hepatic vein for hemodialysis access was first described by Po et al. [24] in a case report in 1994. Since this time, several retrospective studies have sought to verify long-term safety and effectiveness of the transhepatic route for central venous access [11–13]. As with the translumbar route, placement of transhepatic hemodialysis catheters has become commonplace in both the pediatric and adult patient populations. General anesthesia is used at our institution when transhepatic access to the inferior vena cava is requisite in a child.

The technique for transhepatic cannulation of the inferior vena cava is rather straightforward and requires fewer steps than the translumbar route. As with translumbar placement of hemodialysis catheters, antibiotic prophylaxis is controversial and not universally practiced [23]. Pre-procedure ultrasonography of the right upper quadrant is performed to identify a patent middle or right hepatic vein (Fig. 8.1). The right upper quadrant is prepped and draped in the usual sterile fashion. Buffered 1 % lidocaine is administered for local analgesia taking special care to anesthetize the superficial and deep soft tissues including the liver capsule. Using ultrasound guidance, a 21-gauge, 15-cm-long needle is advanced into the middle or right hepatic vein from an anterior subcostal or midaxillary intercostal approach (Fig. 8.2a). The subcostal approach may help to limit future catheter migration [12]. Transhepatic cannulation of a hepatic vein is preferred over direct inferior vena cava puncture because it permits a longer intravascular tract and decreases the chance of migration out of the vessel [11]. A 0.018-in. platinum-tipped mandril guidewire is then advanced through the needle and into the right atrium. Intravascular catheter length is measured and selected in standard fashion. The initial access needle is exchanged over the guidewire for a coaxial transitional sheath (Accustick system, Boston Scientific, Natick, Massachusetts), which permits replacement of the 0.018-in. guidewire with a 0.035-in. guidewire (Fig. 8.2b). In obese patients or in those with cirrhosis, a stiff guidewire may be necessary to facilitate transhepatic passage of the peel-away sheath.

Additional local anesthesia is administered inferior and lateral to the venous entry site, and a subcutaneous tunnel is fashioned. The hemodialysis catheter is pulled through the tunnel and brought out at the initial venous entry site. Over the guidewire, the transitional dilator is exchanged for an appropriately sized peel-away sheath, which is advanced into the hepatic vein. Once the sheath is in place, the inner dilator and guidewire are removed, and the catheter is introduced through the sheath and into the central venous circulation (Fig. 8.2c). Some interventionalists opt to keep a stiff hydrophilic guidewire in place and then advance the catheter through the sheath and over the guidewire into the hepatic vein until the tip lies within the right atrium [20]. Both catheter ports are flushed, heparinized,

Fig. 8.2 Images of a 45-year-old female with end-stage renal disease in whom transhepatic dialysis catheter placement was pursued because she had no remaining peripheral access sites. (**a**) Frontal view of the abdomen. A 21-gauge needle (*open arrow*) has been used to puncture the appropriate hepatic vein. Of note, the venous outflow component of a failed HeRO vascular access device (Hemosphere, Inc., Eden Prairie, Minnesota) is seen within the inferior vena cava (*arrowhead*). (**b**) A coaxial transitional sheath (*arrow*) has been placed over a guidewire into the central hepatic vein near the confluence with the inferior vena cava. (**c**) Dual-lumen hemodialysis catheter has been placed with the tip in the right atrium just beyond the inferior cavoatrial junction (*arrowhead*)



and secured. The initial venous access site is closed using interrupted sutures or Steri-Strips (3 M, St. Paul, Minnesota).

8.5 Complications

Complications of translumbar and transhepatic placement of hemodialysis catheters can be divided into two groups: early (periprocedural) and late. Early complications occur at the time of or immediately following catheter placement and include failure to gain access, guidewire- or catheter-induced atrial or ventricular dysrhythmia, bleeding, air embolism, and catheter malposition or kinking. Acute bleeding following translumbar puncture of the inferior vena cava is quite rare in the setting of acceptable coagulation parameters (INR < 1.5, platelet count > 50,000/mm^3). Rates of air embolism have decreased dramatically with the introduction of valved introducer sheaths several years ago. Most of the other aforementioned immediate complications are avoided with meticulous technique and imaging guidance.

Late complications of translumbar and transhepatic hemodialysis catheters may occur days to months following placement (Table 8.1). One such late complication unique to translumbar hemodialysis catheter placement is spontaneous migration and dislodgement resulting in bleeding. Translumbar catheter migration has been noted to be most common in obese patients, particularly in those with excess adipose tissue concentrated in the truncal area [8, 9]. In such patients, catheter migration or dislodgement out of the inferior vena cava can result in retroperitoneal hemorrhage. According to Biswal et al. [8], bleeding in the form of retroperitoneal hemorrhage has been demonstrated as a common occurrence in several studies. If a translumbar dialysis catheter appears to have migrated on routine or surveillance radiographs, it should be exchanged for a new catheter over a guidewire to facilitate proper placement.

Catheter thrombosis and fibrin sheath formation are late complications common to both translumbar and transhepatic hemodialysis catheter placements. Catheter thrombosis may be treated with outpatient thrombolysis performed through the catheter over 30 min to 1 h. If pharmacologic thrombolysis is unsuccessful, catheter exchange may be performed over a guidewire, thereby maintaining the original access site. Catheter thrombosis rates may be lowered by consistent use of heparin after each hemodialysis session and at the conclusion of placement and exchanges to reduce the risk of intra-catheter thrombosis. Fibrin sheath formation is quite common with chronic indwelling catheters and commonly manifests as catheter dysfunction with impaired ability to aspirate blood despite appropriate catheter tip position on a radiograph. Pharmacologic fibrinolysis and catheter exchange over a guidewire are often the only ways to

Table 8.1 Study comparison – translumbar dialysis catheter placement

	Power et al. [10]	Bennett et al. [7]	Biswal et al. [9]	Lund et al. [6]
No. patients	26 (11 M, 15 F)	22 (10 M, 12 F)	10 (6 M, 4 F)	12
Age (years)	61.9 ± 12.1	37.0 ± 11.9	59 ± 14.2	–
Total catheters	39	29	10	17
Total follow-up	15,864 days	3,510 days	2,252 days	–
Mean catheter duration in situ	–	121 days (14–536)	250 days (30–530)	–
Patients with retroperitoneal hemorrhage	2	1	1	–
Infection rate	2.84 per 1,000 catheter-days	2.80 per 1,000 catheter days	–	2.80 per 1,000 catheter days
Catheter-related bacteremia	0.82 per 1,000 catheter-days	–	–	1.40 per 1,000 catheter days
Exit-site infection	2.01 per 1,000 catheter-days	–	–	–
Catheter thrombosis requiring lysis	0.63 per 1,000 catheter days			330 per 1,000 catheter days

rid a translumbar or transhepatic catheter of a fibrin sheath, as transjugular access for fibrin sheath stripping with a loop snare is often not feasible due to supracardiac central venous occlusion.

Additional late complications of translumbar and transhepatic cannulation of the central veins include infection (Table 8.1) and nonocclusive or occlusive thrombosis of the central veins. Infection can involve the exit site, the subcutaneous tunnel, or the bloodstream. Exit site and subcutaneous tunnel infections are typically caused by skin flora with direct extension from the adjacent skin. *Staphylococcus epidermidis* is the most common organism. In three large retrospective studies detailing experience with transhepatic dialysis catheter placement [11–13], authors noted an infection rate of 0.22–0.24 per 100 catheter days. Unfortunately, infection necessitated catheter removal in nearly all patients because the catheter was presumed to be the nidus of infection

Hepatic tract embolization after elective removal of transhepatic catheters is controversial and to date is a subject that has not achieved consensus on an appropriate course of action [13]. Stavropoulos et al. [11] routinely performed tract embolization with Gelfoam pledgets (Upjohn Pharmacia, Kalamazoo, Michigan). On the contrary, Smith et al. [12] and Younes et al. [13] did not perform hepatic tract embolization after removal of transhepatic catheters, and neither study noted any associated bleeding complications.

Conclusion

Despite ongoing initiatives to reduce catheter use for hemodialysis, a large number of end-stage renal disease patients continue to utilize catheters as a primary mode of access for treatment. Prolonged catheter use eventually leads to the exhaustion of conventional modes of central venous access. The translumbar and transhepatic routes of access require expert technical skill and close surveillance to maintain patency, but each remains an invaluable tool in the armamentarium for interventionalists treating patients that require chronic central venous access for hemodialysis. Translumbar and transhepatic hemodialysis catheters each have proven long-term functionality and provide remarkably durable access in patients who have otherwise exhausted all access options.

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