

Temporary Access and Central Venous Catheters

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The use of central venous catheters for temporary vascular access is a vital part of modern medicine and has an important role in the management of patients with renal failure. Attention to detail when addressing issues relating to temporary venous access, will pay dividends, with significant reductions in morbidity and mortality in both the short and long term.

Keywords: Haemodialysis; Temporary access; Central venous catheters; Tunnelled catheters

Introduction

Whilst obtaining access to the circulation is a routine practical procedure in medicine, the use of central venous catheters has significant morbidity. However, this can be minimised by an understanding of the principles of good practice, together with attention to detail. This article concentrates on haemodialysis associated temporary vascular access but the many of the points made can be generalised to other forms of central venous access, such as in the ITU setting, for the administration of intravenous nutrition or in the general medical ward.

Successful haemodialysis requires satisfactory access to the patient's circulatory system, in order to pump blood through an artificial kidney, at speeds of greater than 350 ml/min. This need has resulted in the development of larger and more sophisticated access devices and to improvements aimed to reduce complications. The world haemodialysis population has grown significantly in the last 10 years and is predicted to grow even further in the coming 10 years (Fig. 1). While vascular access in these patients is usually geared toward the provision of long-term native arterio-venous fistulae, there are a number of situations in which urgent access to the circulation is required and this is usually achieved by the use of dialysis catheters. Such catheters are unavoidable for:

- (1) Patients who present with reversible deterioration in kidney function requiring temporary dialysis.

- (2) Patients whose end stage renal failure has not been previously diagnosed, and who require dialysis as an emergency or whilst awaiting the formation or maturation of permanent vascular access.
- (3) As a bridging modality when a patient's access has failed, whether that be permanent vascular access, or peritoneal dialysis.

It is unlikely that these three groups of patients will reduce in size in the future (unheralded chronic renal failure still accounts for between 20 and 50% of patients entering UK end stage renal failure programmes) and high quality management of temporary venous access will remain a major necessity for nephrologists.

Older forms of temporary access such as the Scribner shunt have now virtually disappeared from most modern units, and dialysis catheters have become the 'norm'. The design of haemodialysis catheters has evolved over time, since first introduced in the late 1960's.¹ These design changes have occurred in response to the demands of the dialysis community and particularly in relation to the requirement for high volume blood flows and reduced infection rates.

Catheter Design

The original catheters used for haemodialysis consisted of two separate single lumen catheters. These were rapidly replaced by dual lumen catheters, which have two co-axial lumens within a single catheter, with the arterial port about 3 cm proximal to the venous port. The recently introduced Tesio catheter has

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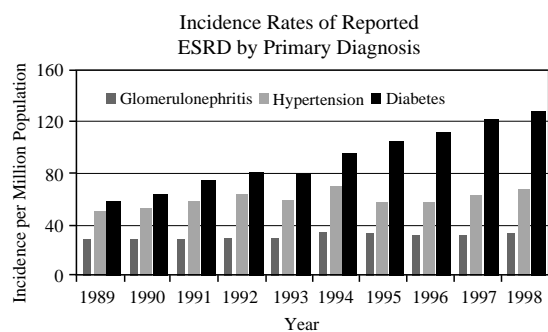


Fig. 1. Incidence rates of ESRD by diagnosis in the USA for the 10 year period (1989–1998).

reverted to the original concept of two separate single lumen catheters, with two individual tubes lying freely within the vein (Fig. 2). The major change in the catheter design over the last 20 years has been the development and increasing use of catheters that can be percutaneously tunneled (usually with cuffs) and which are more suitable for long-term use. The terms acute and chronic access catheters are sometimes used synonymously with non-tunneled and tunneled catheters, respectively, but this is a misnomer since tunneled central venous catheters have as much of a role in temporary access management, as a non-tunneled catheter (Fig. 3).

Most modern dual lumen haemodialysis catheters are formed from polyurethane, which is stiff at room temperature, but which softens at body temperature. These catheters are easy to insert by the percutaneous Seldinger technique. In contrast, soft silicone catheters must be inserted using a peel-away sheath. There are variations in lengths of catheter from tip to hub and also in catheter diameters and there is an increasing move to the use of larger bore catheters, to allow blood flows in excess of 350 ml/min for high efficiency haemodialysis. Much of these design variations are

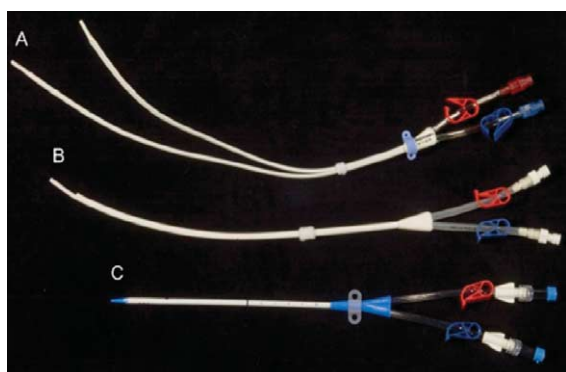


Fig. 2. Design of central venous catheter has developed over the last 10 years (a) ASH split catheter design, (b) standard tunneled catheter with cuff (c) standard non-tunneled catheter.

only important if the catheter is required to provide haemodialysis access for longer than 2 weeks. Otherwise, the cheaper non-tunneled catheters are perfectly adequate for shorter periods of haemodialysis.

Insertion

There are significant complications associated with haemodialysis catheter insertion that vary with the site of the insertion and the catheter type. It is essential that those who undertake central venous catheter insertion should have been appropriately trained and are familiar with its potential complications. Catheter insertion should not automatically be delegated to the most junior member of the team.

The use of real time ultrasound to visualise the vein at the time of insertion is known to reduce the incidence of complications in trained hands (Fig. 4).² Both the National Institute of Clinical Excellence in the UK and the USA KDOQI recommend ultrasound guidance as the preferred method for insertion of central venous catheters into the internal jugular vein (special adapters for ultrasound probes are available for use in subclavian vein catheterisation).

The site for insertion of a temporary dialysis catheter must take into account its associated complications and risks. The femoral and the internal jugular sites are the easiest for central vein catheter insertion, while the subclavian catheterisation has the highest incidence of complications. Unfortunately infection rates for non-tunneled femoral and internal jugular catheters are higher than for subclavian vein catheters, although for tunneled lines this problem is less of an issue.^{3,4} The use of the left internal jugular vein carries difficulties in regard to both complications and placement, as the catheter has to traverse two 90° bends to reach the right atrium (Fig. 5).

It is important to ensure that the catheter tip is appropriately positioned within the right atrium for soft silicone based tunneled catheters, or at the junction of the SVC with the right atrium for non-tunneled polyurethane catheters (in order to avoid the stiffer material damaging the right atrial wall).

There is a high incidence of central vein stenosis and occlusion in patients with subclavian catheters, which may seriously compromise the subsequent ability to form an AV fistula for long-term dialysis access in that arm.⁵ The loss of the access sites of one arm is of considerable importance for that patient's long-term outcome, even with the development of surgical and radiological techniques to decompress the stenoses. Whether the left internal jugular route



Fig. 3. The tunnelled haemodialysis catheter provides a means of both temporary and long-term access to the patient's circulation.

carries a similar risk of central vein stenosis has yet to be substantiated, as the number of patients with left internal jugular catheters in the early studies was small.^{5,6}

There are a number of alternative routes that can be used in patients who have run out of access, or have central vein stenosis. These include direct placement of the central venous catheter in the right atrium, the use of trans-lumbar IVC placed catheters. These are usually used as a last resort, and experience in these techniques is low in most renal units but co-operation across units could allow radiological expertise to be developed on a regional basis.

The most appropriate strategy for temporary haemodialysis access management depends on the anticipated duration of treatment. If this is likely to be less than one week and the patient is hospitalised, a femoral catheter should be considered, although this

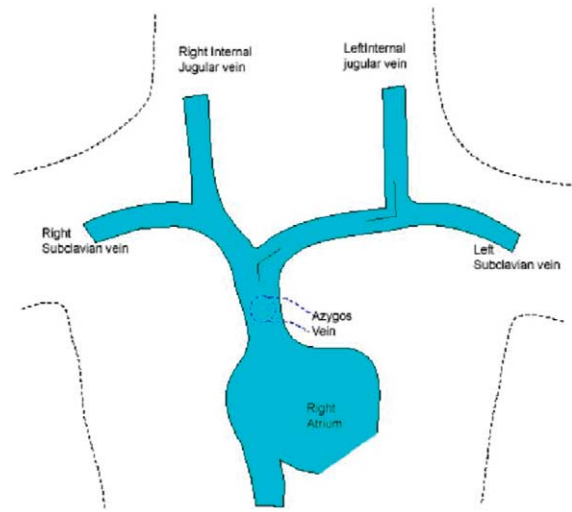


Fig. 5. Anatomical representation of the route taken by a catheter inserted into the left internal jugular vein, illustrating the double right angle route required.

carries a significant risk of infection, and also of femoral vein stenosis and thrombosis. For these reasons it is often best to rotate the catheter every 48–72 h, and to use anti-embolic prophylaxis with TED stockings and subcutaneous heparin. If treatment is likely to be limited to 1–2 weeks, with a reasonable expectation of recovery of kidney function or the maturation of a permanent vascular access, a right internal jugular non-tunnelled catheter is an option. However, for those in whom treatment is expected to extend beyond 2 weeks, it is probably best to start with a non-tunnelled femoral catheter followed by the early insertion of a tunnelled, internal jugular catheter (usually on the dominant side, to preserve the non-dominant arm for a native AV fistula).

Infection and Central Venous Catheters

The major complication of central venous catheters is infection. Numerous studies have confirmed that the risk of both local and blood-borne infections is greater in patients with central venous catheters than those with an AV fistula.⁷ The incidence of infection is greater for non-tunnelled, as opposed to tunnelled catheters and is related to the duration of placement (Table 1). Tesio catheters have been reported to have reduced infection rates, and this has led some units to use them routinely for long-term haemodialysis access.⁸

Catheter-associated infection is a major problem, which can result in septic central vein thrombosis, infective endocarditis, osteomyelitis, septic arthritis

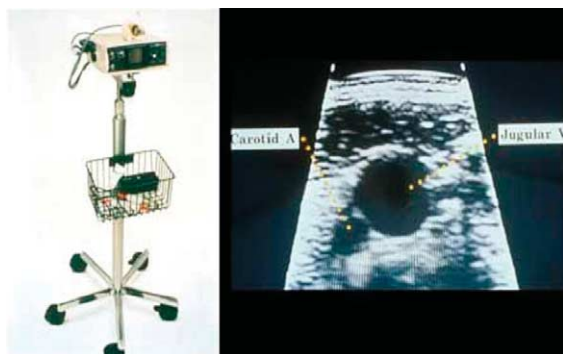


Fig. 4. The SITE RITE 3™ is one of the ultrasound devices available, which allows real time visualisation of the internal jugular vein. The images obtained allow clear definition of the internal jugular vein and its relationship to the carotid artery.

Table 1. Event rate for infectious complications by access type (Dx surveillance network, October 1999–May 2001-Ref. [6])

	Access infections (events)	Access infections per 100 patient months
Autogenous fistulae	130	0.56
Prosthetic graft	421	1.36
Tunnelled catheter	1594	8.42
Non-tunnelled catheter	284	11.98
All access	2429	3.2

and death. Furthermore, indwelling long-term artificial material in immuno-compromised patients such as those on renal dialysis, and who are receiving a variety of antibiotics, provides a rapid breeding ground for the development of resistant organisms. As a result, many of the more serious multi-resistant organisms have first appeared on haemodialysis units.

The high rate of infection not only increases morbidity and mortality, but also has significant economic implications, as infection is the commonest reason for the admission of haemodialysis patients to hospital.

The reduction in the incidence of infection is a major priority of all those using central venous catheters in haemodialysis units, intensive therapy units and within parenteral nutrition programs. Infection can spread either along the inner lumen of the catheter or along the outside of the catheter:

- Infection or colonisation at the exit site is followed by spread down the outside of the catheter resulting in either a tunnel infection in those with tunnelled lines, or blood-borne infection in those with non-tunnelled lines.
- Colonisation of the internal wall of the catheter is a frequent occurrence and is usually associated with the presence of a biofilm. This is produced by a combination of host factors (e.g. fibrinogen and fibrin) and microbial products (e.g. glycocalyx). Within the biofilm the colonising bacteria convert to a sessile form and live in symbiosis with the patient. What determines the development of overt infection is not clearly understood although the concentration of organisms is probably relevant.

The prevention of infection is directed to each of these two portals of entry and a number of guidelines and recommendations have been produced in this rapidly developing field.⁹

Scrupulous aseptic care, at the time of insertion is vital and use of prophylactic antibiotics is of particular relevance to patients who are undergoing insertion of a tunnelled catheter. Prevention of exit site infection requires regular review of the exit site and aseptic dressing change. There is also evidence to support the

use of either chlorhexidine and povidine iodine as cleaning materials, both of which reduce the risk of exit site infections and subsequent septicaemia.¹⁰ Unfortunately, many of these agents are alcohol based, which can result in catheter damage, but this is more important for long term tunnelled haemodialysis catheters than for non-tunnelled catheters, which are likely to be removed within a short period of time.

Mucocutaneous colonisation with specific Gram-positive bacteria such as *Staphylococcus aureus* (*S. aureus*) is associated with an increased risk of exit site infection and subsequent blood borne infection. *S. aureus* is the most significant organism associated with central venous catheter infections and is highly virulent, frequently leading to osteomyelitis and endocarditis, which can be quite aggressive and difficult to treat (the question of methicillin sensitivity is of relevance only to the treatment, but not to the morbidity). Because of this, colonisation should be routinely assessed and treated. Intra nasal mupirocin cream should be used for nasal carriers of *S. aureus*, and may also benefit patients with tunnelled PD catheters.¹¹

The application of mupirocin to the exit site to prevent colonisation with *S. aureus* and staphylococcal septicaemia has been controversial but there are now sufficient studies to recommend its routine use.¹² There has been concern that this could result in mupirocin resistance but this seems to have a low incidence in practice and remains clinically unimportant. Moreover, there does not appear to be any increase in non-staphylococcal infections.

A number of methods have been tried to reduce the spread of infection along the lumen of the catheter. These include the impregnation of the catheters with antibacterial agents, such as silver or antibiotics, which have been found to prevent infections, particularly in ITU but has the risks of patient sensitivity and the development of bacterial resistance. Antibiotic impregnation has been utilised mainly for non-tunnelled catheters and has been associated with a significant reduction in infection in the short term.¹³

Antibiotic locks have also been tried, and there is some evidence that gentamicin locks reduce the rate of infection with both tunnelled and non-tunnelled catheters.¹⁴ Concerns of resistance and toxicity have

so far proven to be unfounded. More recently, taurolidine citrate has been developed as both an anti-thrombotic and anti-bacterial agent. There is some evidence supporting its use as an anti-thrombotic agent and that it reduces the incidence of septicaemia or bacteraemia but not exit site colonisation and infection.¹⁵ Further studies are required before either of these techniques can be recommended for routine use with tunnelled catheters.

It is important for individual units to monitor their local infection rate and the bacterial spectrum, which may depend upon environmental factors such as dialysis water purity.

Treatment of catheter related infection depends on catheter type and the site of infection. Significant exit site infection in a non-tunnelled catheter should prompt consideration for its removal. Antibiotic use should be judicious and take into account both national guidelines and local resistance patterns to reduce the development of antibiotic resistance. Vancomycin use should be minimised. For tunnelled catheters, which are more difficult to change, exit site infections may be treated with local agents and appropriate antibiotics but full-blown tunnel infections, especially with *S. aureus*, may prove difficult to treat and removal of catheter is usually required. Where there is evidence of blood borne infection in patients with temporary lines, the catheter should be removed at the earliest opportunity and appropriate antibiotic treatment commenced. For tunnelled catheters, initial empiric antibiotic regimes should be started and the catheter only removed if markers of infection (fever, white cell count or CRP) have not improved within 48 h. Some such catheters may be salvageable although a prolonged antibiotic course is often required.

Catheter Function

The role of haemodialysis catheters is to provide sufficient access to the circulation to allow blood pump speeds of 300–500 ml/min. Such flow rates can be more readily achieved in tunnelled catheters, which have larger lumens. If the desired flow rate is not achieved, the underlying cause needs to be found. Early dysfunction is usually associated with kinking of the catheter or a poor position, whilst late dysfunction is more usually associated with thrombosis, or a fibrin sheath around the distal end of the catheter.

In an inadequately functioning non-tunnelled catheter the patient's position should first be altered. The catheter should then be flushed with normal saline, using a 10 ml syringe and reversing the lines

considered. While line reversal may increase recirculation, this is usually within acceptable limits for short periods. If all these manoeuvres fail, catheter should be repositioned or replaced.

For tunnelled catheters, urokinase and low-level anticoagulation can be considered although there is no evidence that warfarin prolongs catheter survival. However, if simple manoeuvres fail, changing the line over a guide wire may be the best and cheapest alternative, although it is vital to ensure that it is not simply repositioned in the same suboptimal position.

Bullet Points

- ◆ Temporary access to patients circulation should be undertaken in a planned manner, such that the route and type of access are considered in advance, taking into perspective the patient's clinical condition and likely length of time that the access will be required.
- ◆ The use of tunnelled catheters carries a significantly reduced rate of infection and should be the preferred means of providing access to circulation for periods in excess of 2 weeks.
- ◆ The use of the subclavian route for insertion of central venous catheters, should be used with care in patients who may require long term renal replacement therapy.
- ◆ Femoral vein catheters have a high incidence for the development of thrombosis, and their management should be according to strict protocols with the use of anti-embolic prophylaxis from the time of insertion.
- ◆ Ultrasound guided insertion of central venous catheters is now the standard method for insertion.
- ◆ The optimal care of the exit site, in order to prevent colonisation is of importance in preventing infection and units with a high incidence of *S. aureus* infection should consider the use of mupirocin ointment on the exit site with dressing changes.
- ◆ The use of antibacterial impregnated catheters, and antibacterial locks, do have a part to play in prevention of catheter-associated infection and should be considered in units with high incidences of infection.
- ◆ Early removal of catheters in patients with blood borne infections is vital to prevent subsequent complications including osteomyelitis, and endocarditis.

References

- 1 ERBEN J, KVASNICKA J, BASTECKY J, VORTEL V. Experience with routine use of subclavian vein cannulation in Haemodialysis. *Proc Eur Dial Transplant Assoc* 1969;**6**:59–64.
- 2 RANDOLPH AG, COOK DJ, GONZALES CA, PRIBBLE CG. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med* 1996;**24**:2053–2058.
- 3 MERRER J, DE JONGHE B, GOLLIOT F, LEFRANT JY, RAFFY B, BARRE E *et al*. Complications of femoral and subclavian venous catheterisation in critically ill patients: a randomised controlled trial. *JAMA* 2001;**286**:700–707.
- 4 OLIVER MJ, CALLERY SM, THORPE KE, SCHWAB SJ, CHURCHILL DN. Risk of bacteraemia from temporary haemodialysis catheters by site of insertion and duration of use. *Kidney Int* 2000;**58**:2543–2545.
- 5 SCHILLINGER F, SCHILLINGER D, MONTAGNAC R, MILCENT T. Post catheterisation vein stenosis in haemodialysis: comparative angiographic study of 50 subclavian and 50 internal jugular accesses. *Nephrol Dial Transplant* 1991;**6**:722–724.
- 6 CIMOCHOWSKI GE, WORLEY E, RUTHERFORD WE, SARTAIN J, BLONDIN J, HARTER H. Superiority of the internal jugular over the subclavian access for temporary dialysis. *Nephron* 1990;**54**:154–161.
- 7 TOKARS JL, MILLER ER, STEIN G. New national surveillance system for haemodialysis associated infections: Initial results. *AJIC* 2002;**30**:288–295.
- 8 DUNCAN ND, SINGH S, CAIRNS TD, CLARK M, EL-TAYAR A, GRIFFITH M *et al*. Tesio-Caths provide effective and safe long term vascular access. *Nephrol Dial Transplant* 2004;**19**:2816–2822.
- 9 Guidelines for preventing infections associated with the insertion and maintenance of central venous catheters. *J Hosp Infect* 2001;**47**(Suppl):S47–S67.
- 10 LEVIN A, MASON AJ, JINDAL KK, FONG IW, GOLDSTEIN MB. Prevention of haemodialysis subclavian vein catheter infections by topical povidone-iodine. *Kidney Int* 1991;**40**:934–938.
- 11 Mupirocin Study Group. Nasal mupirocin prevents *Staphylococcus aureus* exit-site infection during peritoneal dialysis. *J Am Soc Nephrol* 1996;**7**:2403–2408.
- 12 WAYNE JOHNSON D, MACGINLEY R, KAY TD, HAWLEY CM, CAMPBELL SB, ISBEL NM *et al*. Randomised controlled trial of topical exit site mupirocin application in patients with tunnelled, cuffed haemodialysis catheters. *Nephrol Dial Transplant* 2002;**17**:1802–1807.
- 13 CHATZINIKOLAOU I, FINKEL K, HANNA H, BOKTOUR M, FORINGER J, HO T *et al*. Antibiotic-coated haemodialysis catheters for the prevention of vascular catheter-related infections: a prospective randomised study. *AJM* 2003;**115**:352–357.
- 14 PRIESTMAN WS, TAAL MW, FLUCK RJ, MCINTYRE CW. Haemodialysis catheter/dysfunction is reduced by catheter restricted filling with gentamicin and heparin. *Renal Assoc Annu Congress* 2005;P91.
- 15 MICHIEL GH, VAN AGTEREN B, VAN AGTEREN M. Prevention of dialysis catheter-related sepsis with a citrate-taurolidine—containing lock solution. *Nephrol Dial Transplant* 2004;**19**:1546–1551.

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