Haemodialysis catheter-related infection: time for action

Bernard Canaud

Nephrology, Lapeyronie University Hospital, Montpellier, France

Introduction

Central venous catheters were a major advance in end-stage renal disease (ESRD) patient care until the burden of catheter-related complications became obvious. Catheter-related infection is one of the major causes of morbidity, with potential lethal hazards in haemodialysis patients. Today, the incidence of bacteraemia ranges from 0.5 to 13 per 1000 patient-days with haemodialysis catheters. Lower rates are observed with permanent silicone catheters (cuffed or non-cuffed) and higher ones with temporary polyurethane catheters. In a recent multicentre prospective study involving 988 ESRD patients it has been estimated that the relative risk of bacteraemia was 7.64-fold higher in patients requiring catheters (n = 58; 5.9%) as compared to those having a native arteriovenous fistula [1]. In order to reduce infections related to the use of haemodialysis catheter, it is time to address the following issues: first, evaluating the burden; second, defining infection-related catheters; third, identifying risk factors; fourth, making recommendations and looking at new technical solutions.

Epidemiological facts

Haemodialysis catheters are widely used in ESRD patients to ensure extracorporeal therapy. Haemodialysis catheters are indicated in two types of situation: first, as a short-term bridging solution, i.e. to permit creation, maturation, or revision of arteriovenous fistula or graft; second, as a long-term solution for patients with exhausted vascular access sites, contraindications to arteriovenous access for medical reasons (heart failure, severe limb ischaemia), or for comfort in elderly patients with poor prognosis. Today one can estimate that 13% (range 5–20%) of patients with ESRD are regularly treated using permanent or temporary central catheters [2]. Blood-stream infections related to haemodialysis catheters represent the most frequent cause of morbidity, accounting for one-third of catheter withdrawals. The incidence of catheter-related infection averages 3.5 episodes per 1000 patient-days (range 0.5–7) for permanent silicone catheters (cuffed or non-cuffed) [3]. This figure compares favourably with the rate of 5 (range 3–20) reported for temporary polyurethane catheters [4].

The site of catheter insertion plays a significant role in the magnitude of the infectious risk. The femoral route is apparently less favourable than subclavian or jugular routes. Important lessons were also learned from clinical experience with the use of long-term tunnelled silicone catheter (cuffed or non-cuffed). Despite such anchoring systems that create a physical barrier to the penetration of micro-organisms on the external surfaces of catheters, these catheters continued to pose a serious risk of blood-stream infections. Corroborating data indicate that colonization of catheters occurs most frequently through the lumen at the time of connecting the hub to the dialysis line, e.g. the low rate of skin or tunnel infection with these tunneled catheters [5]. Therefore one must accept that endoluminal contamination from the connecting hub probably causes production of a microbial biofilm. This virulence factor is frequently unrecognized. Nevertheless, it remains the main source of catheter-related bacteraemia. This phenomenon has been well documented for Staphylococcus epidermidis strains producing slime (glycocalyx), which is responsible for their particular virulence.

Time for definitions

Time has come also for more rigorous definitions and standardization both with respect to terminology and methodology. This is necessary to correctly categorize
infections related to haemodialysis catheter use. For this purpose, it appears that the more appropriate definitions, proposed by the Centers for Disease Control and Prevention, should be adopted. Catheterization period is the length of time in days (or months) a vein is catheterized through the same insertion site. Clinical evidence of catheter infections include local infection (skin-exit or tunnel infection) and/or systemic or blood-stream infection (i.e., bacteremia, sepsis). Contaminated catheter stands for the presence of \( \geq 15 \) c.f.u. on semi-quantitative culture or \( \geq 10^5 \) c.f.u. on quantitative cultures on the distal catheter segment. Catheter-related sepsis is confirmed when the same organism (identical species, antibiogram, plasmid profile) is isolated from the catheter tip and blood from a patient who is clinically septic (fever above 38°C, chills, hypotension, or local infection) with no other apparent source.

To diagnose device-related infection, the removed catheter must be examined using quantitative cultures techniques. Several studies have shown that the highest sensitivity provided by culturing catheter segments (distal, proximal) semiquantitatively on solid media or quantitatively in liquid media, removing organisms by sonication. Blood cultures are essential for the diagnosis of catheter-related blood-stream infection. When catheter sepsis is suspected, blood should be drawn for cultures both from catheter and a peripheral vein. Culturing a clot extracted from the distal end of the catheter and/or blood after local fibrinolysis increases the sensitivity of the procedure.

Standardization is also required to express the incidence of catheter-related infections. This is essential to compare and to evaluate the true impact of preventive and/or curative measures. The cumulative incidence, defined as the number of events divided by the number of catheters, is not sufficient, since it does not take into account the length of exposure to catheter risk. The incidence rate, defined as the number of events divided by the number of days the patient(s) was (were) exposed at risk because of the presence of catheter, is a more appropriate form to express catheter hazards. Such incidence may then be normalized to the number of events for 1000 patient-days. Indeed, such risk should be best evaluated by using life table analysis method (Kaplan–Meier). By this token it is then possible to calculate the cumulative probability of remaining free from catheter-related infection according to time taking into account the reduction of subjects exposed at catheter risk.

**Time for identifying risk factors**

Some ESRD patients appear more susceptible and exposed to more frequent infection when haemodialysis catheters are used. Such high-risk patients must be identified and treated adequately when possible. Among these patients are those with chronic carriage (nasal and/or skin) of bacteria, patients with a stoma (tracheotomy, urostomy, colostomy), postoperative patients, diabetics, severely malnourished (hypoalbuminaemia), elderly, and non-compliant patients. In these circumstances the indication of catheter insertion must be postponed and specific care must be provided.

**Time for new technical solutions and recommendations**

To reduce infections related to central catheters, two types of action must be considered: one concerns technical design and physical properties of the catheter; the other concerns catheter care and handling.

Catheter design has made tremendous progress in the past 15 years. Research on polymers has led to the development of haemocompatible and resistant material such as Teflon, silicone, and polyurethane. Such polymers have permitted the manufacture of disposable catheters with good mechanical resistance and haemocompatibility and adequate performance for haemodialysis. Many investigators advocated the incorporation of ‘active physicochemical properties’ into catheters. In the mid-nineties research has focused on surface treatment of catheters in order to modify surface properties and provide resistance to thrombus formation and/or infection [6]. Several processes were used on common catheter material (silicone and polyurethane). Their biological properties were evaluated in vitro or in vivo. The common quest with surface treatment has been to prevent platelet adhesion and coagulation activation and at the same time to create a micro-environment hostile to invading micro-organisms. This can be achieved by inhibiting bacterial adhesion to the material or by preventing their migration along the plastic surface.

Ion-beam-based processes such as ion implantation and ion-beam assisted deposition of antimicrobial silver coating of silicone rubber were first developed by the Spire Group (SPI-Silicone process). Clinical results reported by Bambauer with 156 silver coated silicone haemodialysis catheters appeared quite exciting. The catheter contamination rate was reduced by 65% [7]. Unfortunately, these positive initial results were not confirmed in a randomized study reported by Trerotola involving 91 ESRD patients [8]. Moreover, in this latter report two silver-coated catheters had to be removed because of allergic reactions to the coating. Antibacterial substances have been also effectively bonded to catheters, especially those made of polyurethane and designed for short-term use (i.e. 30 days) [9]. In a recent randomized double-blind study involving 865 polyurethane catheters inserted in 817 critical care patients, it was shown that catheters impregnated with minocycline and rifampicin were able to prevent 90% of blood-stream infections and appeared significantly less likely to be colonized [10]. It must be mentioned, however, that the duration of catheter placement averaged 8.4 days only (range 1–55 days). Such positive results confirm those obtained in a previous study reported by the same group [11]. Although exciting, one must remain cautious, since
these results were obtained with nutritional catheters. This finding cannot be extrapolated to haemodialysis catheters, for which conditions of use are quite different. The risk of contamination is obviously greater for haemodialysis catheters because of frequent blood line catheter hub connections which facilitate entry of micro-organisms into the lumen of the catheter. Moreover, the stability of antimicrobial bonded substances must be proven over a longer period of time (more than 90 days).

In spite of the progresses of catheter technology, care and handling remain still the most efficient way to prevent catheter-related blood-stream infections. Patients with permanent or temporary haemodialysis catheters are at high risk. Specific and meticulous catheter care must be provided at all times. Catheter-anchoring systems of tunnelled catheters using Dacron cuff or subcutaneous bonding suture offer the best barrier to migration of micro-organisms along the cannula tracks. Dialysis staff have a critical role in prevention and early treatment of catheter infections. Training of care providers and implementation of strict aseptic technique for catheter handling and site care are essential for reducing catheter contamination hazards [12].

In this context, the role of catheter dressing materials appears critical [13]. As shown, plastic transparent dressings are associated with significantly increased rates of skin-exit infection, catheter contamination, and systemic catheter-related sepsis. Replacement of dysfunctioning tunnelled catheter over a guide wire exchange through pre-existing subcutaneous tunnel is a simple and convenient alternative for prolonging haemodialysis catheter life [14]. However, such an attempt for catheter salvaging must be very cautious, since it carries the risk of catheter contamination and delayed septic complications [15]. Such high-risk practice should be abandoned and it is better to consider catheter removal and de novo catheter insertion. Now, recognizing the fact that colonization occurs most frequently through the lumen at the time of connecting hub to dialysis lines, preventive measures must be considered. Frequent destruction and removal of the endoluminal catheter biofilm by means of a fibrinolytic agent (e.g. urokinase) with local instillation of anti-access infections in situ agent (e.g. urokinase) with local instillation of anti-access infections in situ agent (e.g. urokinase) with local instillation of anti-access infections in situ agent (e.g. urokinase) appear to be an effective means for preventing catheter contamination and blood-stream infection.

Conclusion

Certainly the new technology of polymer and catheter manufacturing will provide a new generation (second- or third-generation) of haemodialysis catheters with a ‘bioactive’ surface conferring thromboresistant and infection-resistant properties. However, it must be kept in mind that all sophisticated technological improvements will never replace hygienic and aseptic rules for catheter handling.

References