Hemodialysis International 2006; **10**: 63–67

Comparison of side hole versus non side hole high flow hemodialysis catheters

Michael G. TAL,[1] Aldo J. PEIXOTO,[2] Susan T. CROWLEY,[2] Neil DENBOW,[1] Donna ELISEO,[1] Jeffrey POLLAK[1]

[1]Interventional Radiology, Yale New Haven Hospital and VA Connecticut Healthcare System, New Haven, Connecticut, U.S.A., [2]Nephrology, Yale University School of Medicine, and Renal Section, VA Connecticut Healthcare System, New Haven, Connecticut, U.S.A.

Abstract

Current literature suggests that side holes may be detrimental to dialysis catheter performance. Today, these catheters are primarily available with side holes. The purpose of this study was to compare flow rates, infection rate, and survival of side hole vs. non side hole hemodialysis catheters. Over a 16-month period patients were arbitrarily assigned to either a 14.5 F MAHURKAR® MAXID™ cuffed dual lumen tunneled catheter with side holes or a 14.5 F MAHURKAR MAXID cuffed dual lumen tunneled catheter without side holes ("non side hole catheters"). We performed a retrospective analysis of catheter flow rates, patency, catheter survival, and catheter-related infections. Information was gathered for the life of the catheter or up to 28 weeks. A total of 54 patients were enrolled in the study. Thirty-seven of 54 (68%) patients received a catheter with side holes for a total of 3,930 catheter days and 17/54 (32%) received a similar catheter without side holes for a total of 2,188 catheter days. Catheter infection necessitating removal of the catheter occurred in 10/37 catheters with side holes and 1/17 without side holes. Infection rates per 1,000 catheter days were 2.545 with side holes and 0.254 without side holes ($p < 0.001$). Slightly improved catheter survival ($p < 0.05$) was recorded with the non side hole catheters. No insertion complication (e.g., air embolization, bleeding, or kinking) occurred with either catheter. One catheter without side holes had to be repositioned 5 days after insertion because of poor flows. No significant difference was recorded in mean blood flow rates between the catheters. Results indicate reduced catheter infection rate in hemodialysis patients with the use of non side hole dual lumen tunneled cuffed catheters.

Key words: Dialysis, catheter, infection

BACKGROUND

Most marketed catheters for chronic dialysis today have side holes at the distal tip. Presumably side holes enhance catheter blood flow. To date there is little or no clinical evidence to support the value of catheter side holes in prolonging catheter life or enhancing flow performance.

Correspondence to: M. G. Tal, Interventional Radiology, Yale New Haven Hospital and VA Connecticut Healthcare System, 20 York Street, New Haven, CT 06525, U.S.A.
E-mail: Michael.tal@yale.edu

Twardowski and Moore[1] suggested that side holes at the distal catheter tip are detrimental for the following reasons:

- Loss of heparin locking solution: the heparin does not reach the catheter tip or leaches out from the side holes.
- Side holes created by drilling typically yield rough edges, as seen with electron microscopy. These rough edges may provide anchor sites for clots.
- Clots anchored in the side holes are difficult to remove or dissolve with the use of heparin.

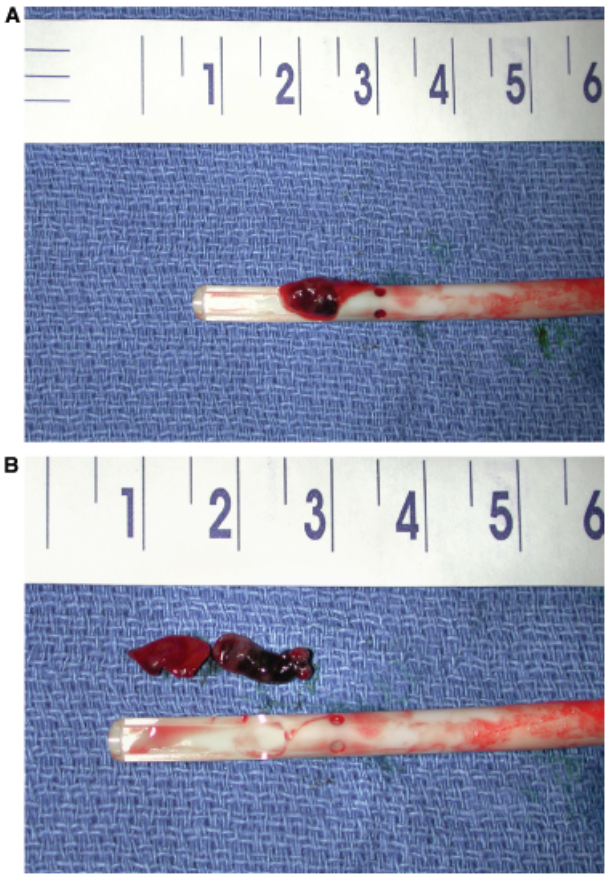


Figure 1 (a) Clot seen at the catheter tip. The clot is anchored in the distal side holes and extends into the catheter. (b) The clot after extraction from the catheter. A cast of the side holes is seen on the distal clot. The lighter color of the distal clot indicates chronicity.

- Clot formation on the catheter beyond the side holes is often seen upon catheter removal (Figure 1a,b).
- Clot is formed on the outer surface, extends through the side holes into the catheter, causing inability to aspirate the distal clot before dialysis.
- If the distal inflow bore is occluded and blood flows through the side holes, it is likely that vein intima is sucked into the catheter side holes. This causes intimal damage contributing to formation of clot and vascular stenosis.

STUDY HYPOTHESIS

Side holes in the tip of a hemodialysis catheter predispose the catheter to clot formation, which decreases catheter life, increases the risk of impaired catheter performance, and increases catheter-related complications such as infections.

MATERIALS AND METHODS

The Human Investigations Committee of VA Connecticut Healthcare System approved the study. We retrospectively evaluated patients who had been arbitrarily assigned to either a 14.5 F MAHURKAR® MAXID™ (Tyco Healthcare/Kendall, Mansfield, MA) cuffed dual lumen tunneled catheter with side holes or a 14.5 F MAHURKAR MAXID (Tyco Healthcare/Kendall) cuffed dual lumen tunneled catheter without side holes over a 16-month period. Catheter assignment was at the discretion of the attending interventional radiologist placing the catheter. Catheter flow rates, patency, catheter survival, and catheter-related infections were collected from the hemodialysis run sheets and patients' medical records. Information was gathered for the life of the catheter or up to 28 weeks.

We recorded patient demographics, underlying diseases and co-morbidities, catheter patency, and catheter survival. Catheter-related infections were defined as documented exit site infections or bacteremias clinically suspected related to the catheter. Implantation technique and complications were recorded as well. All catheters received the same care techniques provided as a standard in the dialysis unit. Catheter ports were locked with heparin with the exception of patients with heparin-induced thrombocytopenia, in whom alteplase was used as the locking solution. No other substances were used for catheter port locking.

Catheter flow rates were recorded in the dialysis unit with the mean blood flow rate measured by the Fresenius 2008K dialysis machine (Fresenius, Lexington, MA, U.S.A.) during each treatment. All patients were treated in the same dialysis unit. Information recorded in every dialysis session included venous and arterial pressures. Data were recorded every 30 min at maximum blood flow (target prescription 350 mL/min). Thrice weekly, measurements during dialysis (averaged for each week) were performed. Information was gathered for the life of the catheter or up to 28 weeks.

Catheter survival was recorded and analyzed. The reason for catheter removal and any morbidity during catheter implantation was recorded. Statistical analysis was performed with the Fisher exact test.

IMPLANTATION TECHNIQUE

An interventional radiologist inserted all catheters. Ultrasound and fluoroscopic guidance was used in all cases. Access was achieved through a low posterior approach to the internal jugular vein. The tip of the catheter was placed in the mid-to-upper right atrium (RA). To confirm appropriate function, catheter flows were checked while

the patient was still on the procedure table, using rapid aspiration with a 20 cc syringe (5 cc/sec). The preferred placement was with the arterial lumen directed toward the tricuspid valve away from the RA wall.

RESULTS

A total of 54 patients were enrolled in the study. Thirty-seven of the 54 (68%) patients received a catheter with side holes for a total of 3,930 catheter days and 17/54 (32%) received a similar catheter without side holes for a total of 2,188 catheter days.

There was no significant difference between the 2 groups in terms of proportion of subjects with diabetes (11 subjects in each group), age, gender (1 female in the side hole group), race, and cause of end-stage renal disease (ESRD).

Catheter infection was observed in 10/37 catheters with side holes and 1/17 non side hole catheters. The difference was not statistically significant ($p = 0.14$) at first inspection. When calculating infection per 1,000 catheter days, however, it was noted that in the side hole group, infection rates were 2.545 per 1,000 days, vs. the nonside hole group, where only one infection was noted for a rate of 0.245 infections per 1,000 catheter days. Thus, non side hole catheters had a lower rate of infection as compared with the side hole catheters. In addition, improved catheter survival ($p < 0.05$) was recorded with the non side hole catheters (Graph 1).

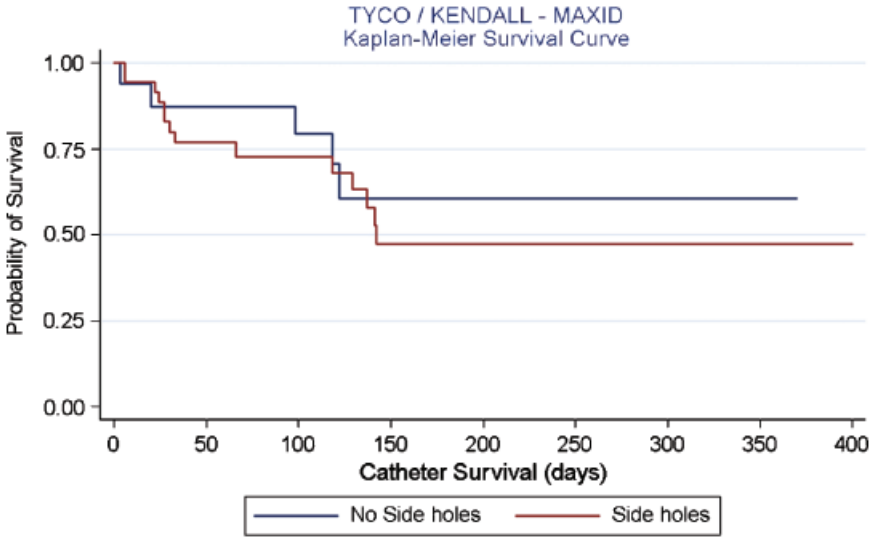
Blood flow rate was reduced in the group with non side hole catheters, though this was not statistically significant. With side holes, the average blood flow recorded was 344 mL/min, compared with 322 mL/min in the non side hole group (Graph 2).

No insertion complications, such as air embolization, bleeding, or kinking, were noted for either group. In the non side hole catheters, small clots that developed in between treatments were easily aspirated before the start of dialysis. Only one[1] non side hole catheter had to be repositioned 5 days after insertion because of poor flows.

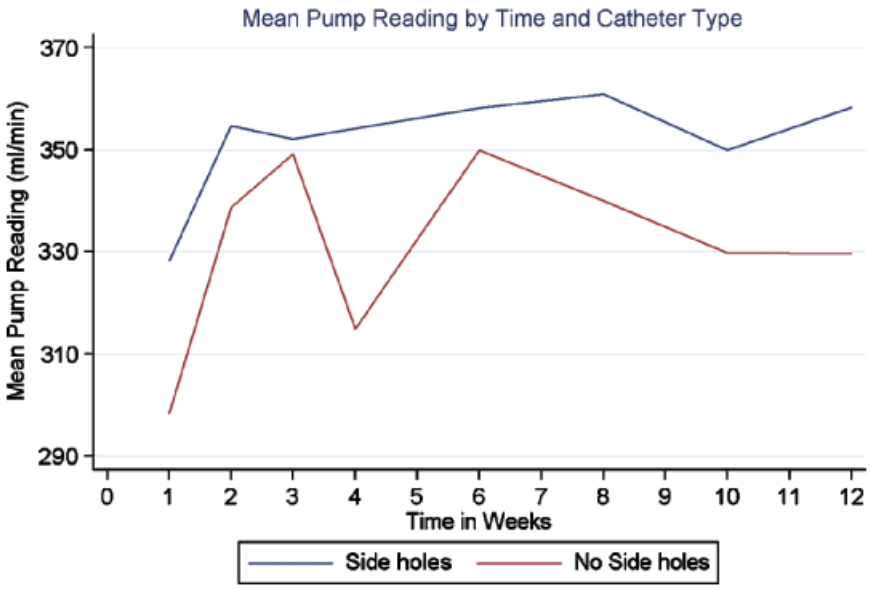
DISCUSSION

In this study, we compared 2 identical catheters with the exception of the presence or absence of side holes at the distal catheter tip. Our intent was to investigate if there were differences in catheter function, flow rates, or infection rate associated with the difference in catheter design. A significant difference in infection rates per 1,000 catheter days was detected between the 2 groups. This study, albeit small and retrospective, suggests hemodialysis patients requiring a catheter may experience decreased infection rates using non side hole catheters as compared with catheters with side holes.

Hemodialysis catheter infection is a common and serious complication. Colonization occurs in 22% to 55% of catheters with overt infection rates of 17%–31%.[2] Infection causing catheter failure occurs in 11% to 28% of catheters and accounts for 28%–73% of catheter failures.[3–5] Exit site infection rates are reported between 0.6 and 4.95 per 1,000 catheter days, and bacteremia rates in recent series are between 2.5 and 5.5 cases per 1,000 catheter days.[6–9] The infection rate with the side hole catheters in this study was within the previously reported



Graph 1 Graph shows survival of the side hole vs. the non side hole catheter over time.



Graph 2 Graph shows flow in the side hole and non side hole catheters over time.

range and was significantly reduced by the non side hole design.

The cause of decreased infection rate in the group with non side hole catheters is not known. According to Twardowski's theory, clotting is more frequent in the tip of catheters with side holes. If this is indeed true, a possible explanation for our finding of increased infection rates with side holes is that distal clots in the catheters with side holes serve as a nidus for infection. ESRD patients have transient bacteremia quite often. The clot on the catheter tip may become infected and because of the side holes and the inability to clear the clot between dialysis treatments, the transient bacteremia becomes a catheter related infection.

Malfunction of long-term hemodialysis catheters has been reported in 17% to 53% of patients.[3–6,8] Broadly defined, this consists of any mechanical problem interfering with its use, including catheter dislodgement as well as poor flow. Malfunction leading to catheter failure has been reported in 10% to 30% of subjects and has been estimated to account for 26% to 72% of all failed catheters, vying only with infection as a leading cause of failure. In this study dislodgement of the catheter occurred in 6% of subjects and accounted for 35% of failed catheters. Inadequate flow rates were seen in 11% of subjects, accounting for the remaining 65% of failed catheters.

The flow rates in the non side hole group in this study were somewhat lower than that in the group with side holes. The difference in flow was not statistically significant, probably because of the relatively small number of patients. The reason for the side holes in the tips of dialysis catheters is to decrease positional occlusion and improve flow rates. If these findings are substantiated in a larger randomized prospective trial, the slightly decreased flow rate may be a necessary, but small, price to pay for the reduced infection rate. Even better, a catheter with improved tip design that would enable enhanced flow without the need for side holes could obviate this potential drawback.

Improved catheter survival was seen with the non side hole group. Paradoxically, one would think that flow limitation because of fibrin sheath formation would be more pronounced in the non side hole group. The significantly decreased infection rate is thus what probably contributed to improved survival in the non side hole catheter group.

For non side hole catheters, accurate catheter implantation with image guidance is essential. To optimize function of the non side hole catheter, we preferred to position the tip of the catheter in the mid-to-upper RA, with the arterial lumen facing toward the tricuspid valve, away from the RA wall. In addition, we verified adequate aspiration before suturing the catheter in place by rapid aspiration with a 20 cc syringe through both lumens. If blood flows freely into the syringe, immediate postplacement malfunction because of catheter malposition is less likely. Using this approach, only one patient in our series had to be brought back to the procedure room to have his catheter repositioned.

There are several limitations to the study. The first is the retrospective and non-randomized design. The catheters were assigned arbitrarily, introducing a potential for selection bias. A second limitation of the study was that only a single manufacturer's catheter was studied. Results of a study using another manufacturer's catheter with and without side holes might produce different results based on other design characteristics of that device. Larger, randomized trials to answer whether side holes at the tip of chronic dialysis catheters are beneficial or detrimental are needed.

In conclusion, in this preliminary retrospective study, non side hole catheters were associated with a lower catheter-associated infection rate and longer catheter survival vs. side hole dialysis catheters. The reasons for the improved survival and reduced infection rate are not known, but due to the magnitude of the problem of catheter related infections and their notorious poor long-term functioning, these questions deserve further investigation. A cautionary note is that the reduced infection rate from the lack of side holes may come at the price of reduced blood flow rate.

Manuscript received June 2005; revised October 2005.

REFERENCES

1 Twardowski ZJ, Moore HL. Side holes at the tip of chronic dialysis catheters are harmful. *J Vascular Access*. 2001; **2**:8–16.

2 De Moor B, Vanholder R, Ringoir S. Subclavian vein hemodialysis catheters: Advantages and disadvantages. *Artif Organs*. 1994; **18**:293–297.

3 Shaffer D, Madras PN, Williams ME, D'Elia JA, Kaldany A, Monaco AP. Use of Dacron cuffed silicone catheters as long-term hemodialysis access. *ASAIO J*. 1992; **38**: 55–58.

4 Mosquera DA, Gibson SP, Goldman MD. Vascular access: A 2 year study and comparison with the Permacath. *Nephrol Dial Transplant*. 1992; **7**:1111–1115.

5 Swartz RD, Messana JM, Boyer CJ, Lunde NM, Weitzel WF, Hartman TL. Successful use of cuffed central venous hemodialysis catheters inserted percutaneously. *J Am Soc Nephrol*. 1994; **4**:1719–1725.

6 McDowell DE, Moss AH, Vasilakis C, Bell R, Pillai L. Percutaneously placed dual-lumen silicone dialysis catheters for long-term hemodialysis. *Am Surgeon*. 1993; **59**:569–573.

7 Capdevila JA, Segarra A, Planes AM, Ramirez-Arellano M, Pahissa A, Piera L, Martinez-Vazquez JM. Successful treatment of haemodialysis catheter-related sepsis without catheter removal. *Nephrol Dial Transplant*. 1993; **8**:231–234 (all controlled with antibiotics, so no catheter failures here).

8 Lund GB, Trerotola SO, Scheel PF Jr, et al. Outcome of tunneled hemodialysis catheters placed by radiologists. *Radiology*. 1996; **198**:467–472.

9 Allon M. Dialysis catheter-related bacteremia: Treatment and prophylaxis. *Am J Kidney Dis*. 2004; **44**: 779–791.