Interventional ORIGINAL ARTICLE

Managing the Failing Dialysis Permacath: Results from a 5-year Retrospective Analysis

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ABSTRACT

Purpose: To evaluate the results of a retrospective analysis on the management of failing permanent dialysis catheters.

Material and Methods: Within 5 years (1/2011-12/2015), 1,158 permanent dialysis catheters were inserted to 853 patients (576 men, 67.5% -277 women, 32.5%) in our department. Of those, 648 patients had only one catheter placed while 205 patients had ≥2 catheters/interventions, reaching a total of 510 procedures (2.48 procedures/patient; 2-27). In 342 cases, catheters were placed to the jugular vein (J-group) and 168 catheters were placed in the femoral vein (F-group). In 413 cases only catheter exchange took place (CE-group), in another 89 cases balloon angioplasty was performed (PTA-group) and in 8 cases a bare metal stent was inserted (BMS-group). 272 central venous catheter (CVCs) had a split tip (SP-group) and a 238 straight tip (ST-group). Outcome measures included intervention-free period and independent predictors that might influence patency.

Results: Mean follow up period was 475.64 days (1-1712 days). Mean intervention-free period was 268.35 days (1-1545 days). According to the Kaplan Meier survival analysis, there was statistically significant difference in favour of the J-group (Median Survival: 136 days *vs.* 69.5 days for F-group, $p<0.0001$). CE-group had significantly better results, when compared to PTA-group and BMS-group (Median Survival: CE-group 116 days, PTA-group 89 days, BMS-group 73 days, $p<0.0001$). CVCs with a straight tip had significantly better intervention-free period compared to split tip (ST-group 126 days *vs.* 80 days for SP-group, $p<0.001$)

Conclusions: Jugular access had significantly better patency results compared to femoral. Additional interventions (angioplasty and stenting) in a bail-out setting provided worse results compared to plain catheter exchange. Straight tip CVCs had significantly better patency rates.

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1. Introduction

"Permanent" central venous catheter (CVC) is an integral part of haemodialysis (HD). Despite the initiative of "fistula first" and its later amendment adding "catheter last", everyday life definitely involves CVCs [1, 2]. Either in the initial immediate steps of renal replacement therapy, as a bridge between an old and a new arteriovenous fistula (AVF) or graft (AVG), or when vascular access sites are exhausted, CVCs are essential for HD patients. CVCs can provide immediate access, do not need maturation time and are widely available [3]. However, their placement is subjected to complications and consequences. The main ones include infection, extended hospitalisation, CVC dysfunction, central venous stenosis and occlusion, increased mortality and health care costs [2]. Among the most important complications are infections (exit site and tunnel, subjecting HD patients to increased use of antibiotics) and central venous stenosis [4-6]. The latter constitute a major problem not only because of their immediate effect, being inadequate dialysis, but also because of the possible exclusion of a vascular access creation on the ipsilateral limb in the future. Superior Vena Cava variant anatomy and catheter tip placement have also been implicated with decreased CVC patency rates [7]. Lately, split catheter tip morphology has also been incriminated with catheter dysfunction compared to straight tip [8].

When dysfunctional, and in the frame of a HD patient with no other options, CVC needs to be exchanged for a new one. A direct, plain catheter exchange may not be possible if stenosis is present and further treatment is needed. Angioplasty (PTA) is the standard of care for central venous stenosis in dialysis patients [9]. There are cases however, where elastic recoil occurs, immediately reducing vascular diameter of the treated vessel. Bare metal stenting is used as a bail-out option, when PTA fails. Lately, covered stents are proposed as a valid alternative to BMS showing improved patency rates for both AVGs and AVFs [10].

The aim of this study was to evaluate the results of the possible treatments in cases of non-functioning CVCs in patients on HD.

2. Material and Methods

2.1 Study characteristics and baseline variables

This is a single-center, retrospective analysis evaluating the results of different options available for the treatment of HD patients with failing permanent CVCs. All procedures performed were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments. Patients signed an informed consent form before the procedure, but as this was a retrospective analysis, additional dedicated informed consent was not applied.

From January 2011 to December 2015 (5 years), 1,158 tunneled CVCs were inserted to 853 patients (576 men, 67.5% -277 women, 32.5%) in our department. Of those, 648 patients had only one catheter placed or no follow up was available and were excluded from the analysis. Two hundred and five (205) patients [112 men (54.6%) -93 women (45.4%); age 53.4 ± 22.2 years] were finally included in the analysis having ≥2 catheter placement interventions (**Table 1**). Reasons for catheter exchange were infection (62/510, 12.15%), catheter dysfunction during dialysis (239/510, 46.86%), vascular stenosis needing further treatment (107/510, 20.10%), and other (4/510, 0.8%). In total, these 205 patients underwent 510 procedures (2.48 procedures/patient; 2-27). Out of these 510 procedures patients had their 342 CVCs placed in the jugular vein (J-group) and in the rest 168 cases in the femoral vein (F-group). In 413 cases only catheter exchange took place (CE-group), in another 89 cases balloon angioplasty was performed (PTA-group) and in 8 cases a self-expanding bare metal stent was inserted (BMS-group). The study diagram is shown in **Fig. 1**.

From the 510 tunneled CVCs inserted, 272 had a split tip (SP-group) and 238 a straight tip (ST-group). Catheters used in our department during this period were: Equistream® and HemoStar® (BARD PV, Tempe, AZ, USA), SplitCath® and Hemo-Flow® (MedComp, Harleysville, PA, USA), DuraMax® and DuraFlow™ (Angiodynamics, Latham, NY, USA) and Palindrome™ (Parkway, MN, USA). Mean catheter length (tip to cuff) was: 28.23 cm (19-55 cm).

Table 1: Baseline variables		
Patients	205	100%
Women	93	45.37%
Men	112	54.63%
Age (years)	53.4 ± 22.2	
Interventions	510	100%
Catheter Exchange	413	80.98%
Balloon Angioplasty	89	17.45%
Diameter (mm)	12.6 ± 3.2	
Length (cm)	4.2 ± 2.2	
BMS insertion	8	1.56%
Diameter (mm)	13.2 ± 4.0	
Length (cm)	5.5 ± 3.5	
Catheters		100%
Split	272/510	53.33%
Straight	238/510	46.66%
Size (cm)	28.2 (19-55)	
Site of Insertion		
Jugular vein	342/510	67.05%
Femoral vein	168/510	32.94%
Side of Insertion		100%
Left	123/510	24.12%
Right	387/510	75.88%
Reason for exchange		
Infection	62/510	12.15%
Dysfunction	239/510	46.86%
Vessel Stenosis	98/510	19.21%
Catheter thrombosis	107/510	20.10%
Other	4/510	0.8%
Complications		
Prolonged bleeding at skin site	123	
Pneumothorax	1	
Carotid puncture	2	

2.2 Protocol followed for failing permacaths

According to the department's protocol a patient is referred from the dialysis center for catheter check and exchange in cases of suspected catheter infection, inadequate dialysis or catheter thrombosis. In case that infection was present, the catheter was removed and a new catheter was placed in another position.

When inadequate HD or catheter thrombosis was the reason for the patient's visit, the catheter's function was checked from a nurse and in case of thrombosis, a total of 5 mg of rTPA were injected to both lumens in a volume matching catheter luminal volume. Patency was evaluated 20 minutes later with a syringe filled with saline and if catheter condition was not changed, the patient entered the angio-suite for catheter exchange.

The catheter was fluoroscopically checked for position accuracy and a hydrophilic wire was introduced in one lumen. The catheter was then partially retrieved and venography (DSA: digital subtraction angiography) was performed from the other lumen to exclude stenosis of the central vein and thrombus or fibrin sheath presence. If no angiographic signs of luminal stenosis were present, the catheter was exchanged for a new one and adjustment of tip's position was performed in order to end up about 2 vertebrae below the trachea bifurcation, the fluoroscopic site of the upper part of the right atrium junction. In the case of a CVC inserted via the femoral vein, the catheter tip was placed just above the hepatic veins.

When stenosis, occlusion or fibrin sheath presence were observed on DSA, the catheter was removed and balloon angioplasty was performed. The balloon's diameter was selected based on visual estimation in orthogonal views. The balloon was inflated to the nominal pressure, unless the patient feels extensive pain or discomfort. In case of suboptimal angiographic result (residual stenosis >30% on visual estimation) a second prolonged inflation was performed either with a balloon of the same diameter or 1 mm higher, depending on operator's discretion. If no direct angiographic improvement, but indirect signs of improved flow were observed (diminished collaterals, faster contrast medium velocity, etc.) no further action took place and the procedure was terminated with the insertion of a new catheter. In case of residual stenosis, a BMS was placed.

According to department's protocol, jugular access was initially preferred whereas femoral access was reserved as a last resort. Femoral catheter was placed straight down under the skin (not in a looped fashion) with its dual lumen outer tip to the femoral region. No additional devices/options for HD are available in our department.

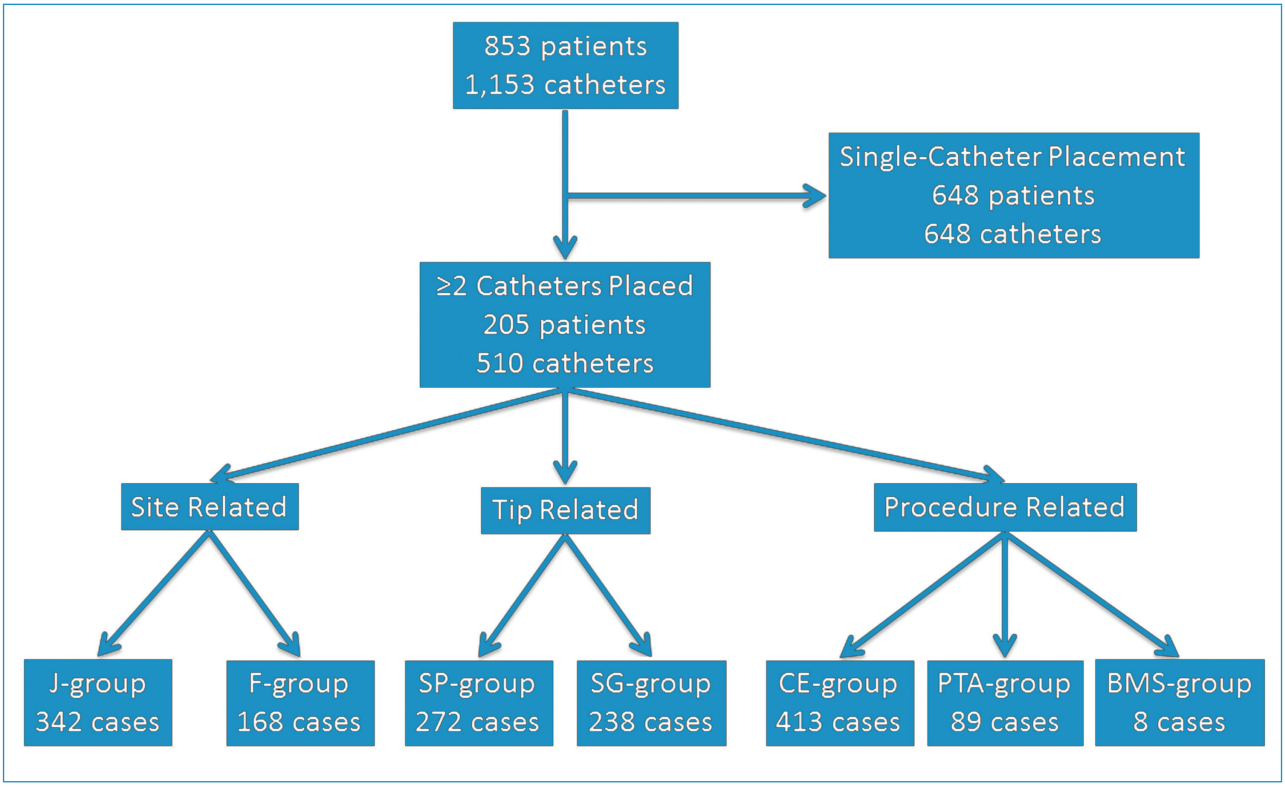

Fig. 1: *Flowchart of the study*

2.3 Outcome measures

Primary outcome measure was intervention free-period, defined as the period between initial catheter insertion and catheter exchange. Secondary outcome measures included investigation of factors influencing primary outcome.

2.4 Statistics

Statistical analysis was performed using the GraphPad PRISM statistical software package (GraphPad PRISM version 5; San Diego, California, USA). Discrete variables were presented as counts and percentages. Continuous variables were expressed as medians and interquartile ranges in parentheses or as means ± standard error (SE). Subgroup analysis was performed to compare intervention free period between different interventions, different catheter tips and access sites. Kaplan-Meier life-table analysis was implemented for the estimation of primary outcome measure and subgroup analysis.

3. Results

Mean follow up period was 475.64 days (1-1712 days). According to the Kaplan Meier survival analysis, mean intervention-free period was 268.35 days (1-1545 days).

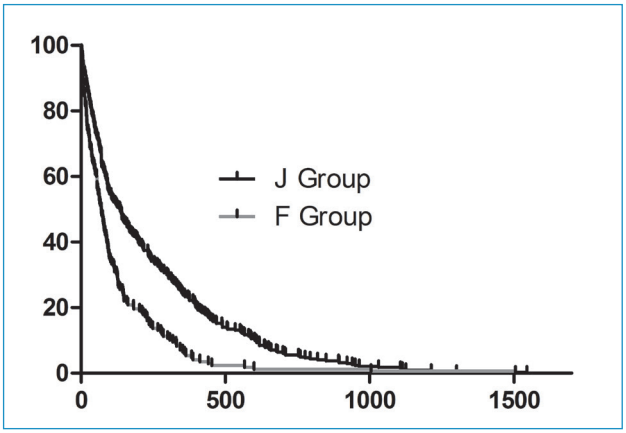

Fig. 2: *Kaplan-Meier Survival Analysis demonstrating significant difference in intervention-free period between femoral (F-group) and jugular (J-group) access (median survival: 136 days for J-group vs. 69.5 days for F-group; p<0.0001). (X axis: Days)*

Reasons for catheter exchange were infection (62/510; 12.15%), dysfunction during dialysis (239/510; 46.86%), vessel stenosis (98/510; 19.21%) and catheter thrombosis (107/510; 20.10%). A statistically significant difference was observed when catheters were placed to the jugular

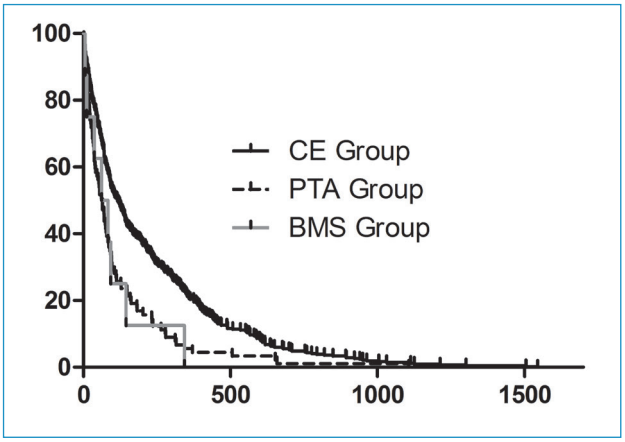

Fig. 3: *Kaplan-Meier Survival Analysis comparing different types of interventions during catheter exchange: Plain catheter exchange (CE-group), angioplasty (PTA-group), bare metal stenting (BMS-group). Plain catheter exchange had significantly better results compared to the other procedures (median survival: CE-group 116 days, PTA-group 89 days, BMS-group 73 days; p<0.0001). (X axis: Days)*

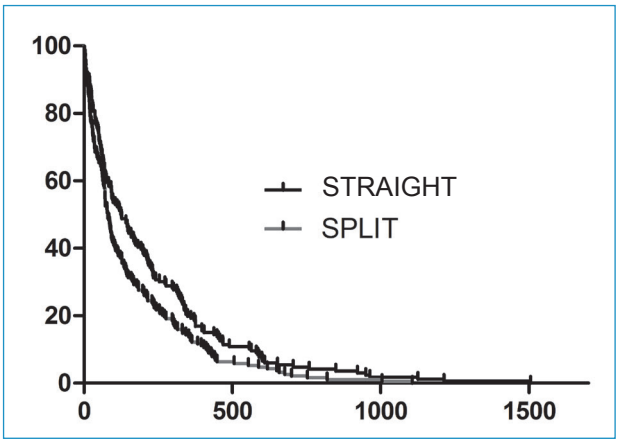

Fig. 4: *Kaplan Meier Survival Analysis comparing intervention-free period of catheters with different tip; split tip (SPLIT) and straight (STRAIGHT) (ST-group 126 days vs. 80 days for SP-group; p<0.001). (X axis: Days)*

vein compared to the femoral access (median survival: 136 days for J-group *vs.* 69.5 days for F-group; $p<0.0001$) (**Fig. 2**). When the procedure did not involve any further intervention to the vessel where the catheter was placed, intervention-free period was significantly longer compared to the case where a BMS was inserted or balloon angioplasty took place (median survival: CE-group 116 days, PTA-group 89 days, BMS-group 73 days; $p<0.0001$) (**Fig. 3**). Finally, CVCs with a straight tip had significantly better intervention-free period compared to those with a split tip (ST-group 126 days *vs.* 80 days for SP-group; $p<0.001$) (**Fig.4**). Complications included carotid artery punctures in 2 patients which required manual pressure, pneumothorax in one patient which was treated conservatively with overnight observation in the hospital and prolonged bleeding from the access site at the skin in 123 patients who had to remain in the department for an additional period of time (usually a couple of hours).

4. Discussion

When running out of options, CVCs provide a valid "lifeline" extension to HD patients. Under these circumstances CVC function and preservation is indisputable. Unlike the HD vascular access circuits (fistulae and grafts), CVC dysfunction eventually leads to catheter exchange. This process may be complicated due to the actual cause of catheter dysfunction. In the case of an infected catheter a new access site should be created, whereas in the case of vascular stenosis further treatment interventions should take place and provide an adequate vascular diameter for the newly placed catheter to function properly. Apart from flow dynamics and the inherent problems of HD patients namely oxidative stress, uraemia and inflammation contributing to central venous stenosis to fistulae and grafts, catheters, as a foreign material, constitute a constant irritating factor to the vascular wall, further accelerating the cascade of events leading to stenosis [11]. Fibrin sheath formation, characteristic of CVCs, is an additional factor leading to stenosis.

Balloon angioplasty has been proposed as the gold standard treatment method. In our study, patency rates in cases where angioplasty was performed were significantly lower compared to those with plain catheter exchange. This can be explained by the fact that angioplasty is usually performed in the later stages of CVC natural history when the vascular wall is already compromised from continuous catheter use. Stent insertion is reserved as a bail-out option when angioplasty fails due to elastic recoil. A recent observational study by Rajan et al. concluded that elastic recoil does occurs, its presence however does not influence patency rates [12]. Stent grafts have been proposed as a valid alternative to BMS in case of central venous stenosis in dialysis access circuits and could therefore have a role in

the setting of CVCs [10]. Paclitaxel-coated balloons, already tested in HD to treat dysfunctional dialysis access circuits, could also play a role in central stenosis treatment [13-16].

Variant anatomy of the superior vena cava, the right atrium shape and the level of catheter tip placement have also been implicated with catheter dysfunction. In a cadaveric study of ten human atria the interesting finding of a "superior vena cava valve" just at the junction of the vein and the right atrium was described. This valve could act as a thrombogenic area leading to catheter dysfunction [7]. Additionally, placement of the catheter tip is performed with the help of two-dimensional fluoroscopy anatomical signs. Although visual estimation of catheter tip placement is adequate for the majority of cases, misplacement could occur. What is more, right atrium shape and size also seem to play a role in catheter function as CVC tip ends up there. There is also an ongoing discussion regarding the shape of the catheter and its tip and the relation with CVC patency rates. In our study straight catheters had significantly better results with regard to intervention-free period, a similar observation made in a recent study by Petridis et al. [8].

5. Limitations

The inherent problems of a retrospective analysis are among the main limitations of this study. Although this was a single-center study, the fact that CVCs are inserted in our department by four different consultants, inevitably varying in placement methodology, is also a limitation. Finally, for statistical purposes, different types of catheters with regard to their technology characteristics were divided in only two groups.

6. Conclusion

In this retrospective study results showed that jugular access had superior intervention-free rates compared to femoral access and plain catheter exchange is also correlated with improved intervention-free period compared to treatment requiring additional procedures. Finally, split tip catheters had significantly worse intervention-free period compared to straight ones.

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Conflict of interest:

The authors declared no conflicts of interest.

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