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Tunneled Hemodialysis Catheters – The Benefits Are Greater

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1. Abstract

1.1. Background: Vascular access is of prime importance for hemodialysis patients. The aim of this study is to show acute (AC) and chronic (CC) complications during the insertion and the usage of Tunneled Catheters (TC) in a single Bulgarian hemodialysis center.

1.2. Material and Methods: This study is retrospective for five years' period, between 1st January 2010 and 31st December 2014. There are 501 TC inserted with different size and tip design in the right/left internal jugular vein (R/LIJV), the Right/Left Supraclavicular Vein by the Supraclavicular approach (R/LSCVSC), the Left Subclavian Vein by The Infraclavicular approach (LSCVIC) and in the Left Femoral Vein (LFV), respectively.

The distribution by sex, age, reason for hemodialysis treatment, primary patency, number and kind of AC and CC as well as the relationship between the complications and the insertion place are calculated.

1.3. Results: There are 262 males with middle-age of 60.3 (+/- 12.8) years and 239 females with middle-age of 61.7 (+/- 11.5) years. We find 6 cases (1.2 %) of AC – 4 of displacement and 2 of malignant arrhythmia. There was 86 (17 %) cases of CC: 43 (8.5 %) – infectious complications, 22 (4.3 %) – thrombosis (intra- and extraluminal), 12 (2.4 %) – mechanical damage and 9 (1.8 %) of central vein stenosis. No significant correlation ($p>0.05$) is observed between the CC and the insertion place. We ascertain significant correlation ($p=0.0001$) between the diameter of the catheter and its patency. The median primary patency was 388 days.

1.4. Conclusions: We conclude that the cannulation of the central vein for hemodialysis can be successfully executed by nephrologists. We have not found correlation between the chronic complications and the insertion place, but we ascertain statistical relationship between the diameter of the catheter, its left insertion place and the better primary patency.

2. Introduction

The hemodialysis vascular access in patients with chronic kidney failure persists as a critical issue in the modern dialysis era. Despite efforts to increase the proportion of hemodialysis patients with permanent vascular access, a significant proportion of them continue to receive treatment through central venous catheters. In fact, tunnel catheters are the most widely used vascular access to initiate hemodialysis treatment. In the United States, 60-82% of patients begin hemodialysis with catheters. In the ideal scenario, they should be temporary vascular access, but the data show that use for months or years; up to 40% of patients have catheters more than 90 days after the start of their hemodialysis treatment [1, 2, 3].

According to the Dialysis Outcomes and Practice Patterns Study (DOPPS), patients with average share of the hemodialysis temporary catheters is 4% in Europe and 15% in the USA; over 33% of the hemodialysis patients in Canada use tunneled catheters as a vascular access [4, 5]. The usage of hemodialysis catheters increased from 2 to 3 times in Italy, Germany, France and Spain over the period between 1996 and 2007, and this is not related to presence of comorbidities. In non-diabetic patients between 18 and 70 years of age, usage of catheters increased 2 times in the USA and

more than 3 times in the European countries, mentioned above, over the same period [6, 7]. Tunneled catheters are introduced into medical practice after 1987, as an alternative to temporary ones. The presence of a polyester cuff, located at no less than 2 cm from the catheter's exit site, is a prerequisite to the drastic reduction of the frequency of catheter-related infections [7, 8, 9, 10]. The use of tunnel catheters is recommended if hemodialysis treatment is required for more than three weeks [11]. Complications, seen with their usage are early (acute), related to the catheterization and late (chronic) – consequence to their exploitation [11, 12].

3. Materials and Methods

This is a retrospective study, covering a period of 5 years, between January 1st 2010 and December 31st 2014.

All patients signed an informed consent before the procedure approved by the Ethics Commission at Medical University-Pleven. The tunneled catheters were used only for patients who need long-term hemodialysis. The catheters' insertion was performed under permanent ultrasound control, while a post-procedure radiography was performed only on patients under suspicion for wrong catheter positioning or catheter, placed on the left side of the chest.

When analyzing the results, the following parametric tests were used to check hypotheses with normal or close to normal case distribution: t-test, ANOVA with post hoc tests Turkey, Scheffe, Bonferroni, Newman-Keuls, Duncan and nonparametric tests for abnormal case distribution: Pearson's chi-squared test ($\chi 2$), Mann-Whitney, Kruscal-Wallis, H-test. The significance of the results, illations and conclusions was determined with $p<0.05$.

A total of 501 Tunneled Catheters (TC) were inserted. Patient distribution by gender shows, that 262 (52%) are men, while 239 (48%) – women. Median age of males was 60.3±12.8 years, for females - 61.7±11.5 years. The difference between the genders in the amount of patients and their median age is not statistically significant ($p>0.05$).

Apart from the diameter, catheters also differed by the design of the tip: asymmetric (shotgun tip*) – 380 catheters; symmetric (palindrome) – 52 and Split tip catheters – 69 catheters. The diameter of the catheters was13.5, 14.5 and 15 Fr. Tunneled catheters were inserted bilaterally in the internal jugular veins, subclavian veins by supra- and infraclavicular approach and in the left femoral vein – six insertion places in total (Figure 1).

We have ascertained acute complications, related to the insertion of tunneled catheters in only six cases (1.2%). Four of them (0.8%) were with displacement of the catheter's tip and the other two of them (0.4%) - malignant ventricular arrhythmia was registered. The distribution of acute complications in relation to the insertion places of tunneled catheters shows that in half of the cases with catheter displacement (two patients), as well as in the two cases with malignant ventricular arrhythmia, the catheter was inserted in the right jugular vein. The correlation between acute complications and insertion place of the catheter is statistically significant ($p<0.05$; coefficient of correlation, $r=0.23$).

We have ascertained 86 chronic complications in total as follows: infectious complications – 43 (8.5%), mechanical damage of the catheter – 12 (2.4%), catheter-associated thrombosis – 22 (4.3%) and catheter-associated stenosis of a central vein – 9 (1.8%). In one patient we found the presence of two complications at the same time – catheter-associated local infection and thrombosis.

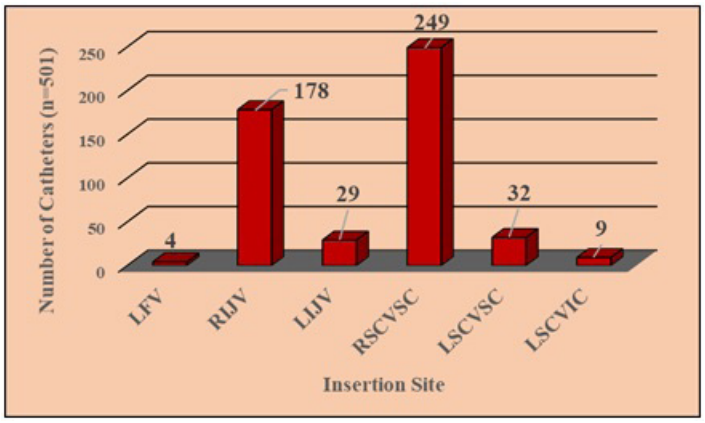

Figure 1: Distribution of catheters according to their insertion place (n=501).
(LFV – left femoral vein; RIJV/LIJV – right/left internal jugular vein; RSCVCS/LSCVSC – right/left subclavian vein by supraclavicular approach; LSCVIC – left subclavian vein by infraclavicular approach.

3.1. Catheter-Associated Infections: We ascertained 43 (8.5%) cases of Catheter-Associated Infection (CAI). Thirty-seven (86%) of these cases were catheter-associated sepsis (CAS), three (7%) were catheter-associated local infection (CALI), and there was a combination of local and systemic infection (CAS +). CALI) in three other patients.

A bacterial cause was found only in 23 (53%) of all 43 cases of catheter-associated infection.

Seventeen (74%) of those cases with specified bacterial causes are Gram (+) bacteria and cocci (G (+)) and the other six (26%) were Gram (-) bacteria (G (-)). The most common G (+) bacterium it was Staphylococcus aureus - in 15 cases (88%); Staphylococcus epidermidis was isolated in only 2 cases (12%). The most common G (-) bacterium it was Pseudomonas aeruginosa in 5 patients (83%) and Escherichia coli in 1 patient (17%). The total residence of TC in our study was 194,416 Catheter-Days (CD), so the relative share of infections was 0.2 / 1000 CD.

3.2. Mechanical Damage to The Catheter: We found mechanical damage which lead to the catheter dysfunction in 12 patients (2.3%). These mechanical complications include: detachment of fixative sutures before the 30-th day, leading to self-removal of TC; mechanical damage to the extraluminal part of the catheter; rupture of the catheter's corpus; spontaneous migration of the

whole catheter's tip or part of it.

3.3. Stenosis of A Central Vein: We found stenosis of a central vein in 9 cases (1.8%). In all of them there was lack of clinical data as described in the literature which is characterized by edema of the homolateral arm and malfunction of the catheter. In two of the cases the clinical manifestation was edema of the infraclavicular zone and/or the homolateral half of the face. All of the cases of stenosis of a central vein were confirmed by phlebography. The differences in the incidence of this complication according to the different localizations of the catheter are not significant in our research (p>0.05).

3.4. Thrombosis of The Catheter: We established 22 cases (4.3%) in total of catheter-associated thrombotic complications. The distribution by insertion place did not show statistically significant difference (p>0.05). In most of the cases we established the presence of a fibrin cuff (Figure 2) around the catheter and only in single cases – intraluminal thrombosis (Figure 3).

Figure 2: A fibrin cuff around the catheter

Figure 3: Intraluminal thrombosis of the Catheter

3.5. Patency of Catheters: The total stay of all TC we have inserted it was 194, 416 Catheter-Days (CD). The average patency of one catheter it was 388±330 CD. The comparison between the average patency of the catheters according to the insertion place shows that the catheters, inserted in the left jugular vein, have the highest patency – 543±423 days. We ascertained statistically significant differences (p=0.01) between the patency of the couples LFV-LIJV, LIJV-LSCVIC, LIJV-RSCVSC, LSCVIC-RIJV. There was no significant difference (p>0.05) in the patency of catheters, inserted in the most often used insertion places (RIJV-RSCVSC) – (Figure 4).

The data from our study shows that on the 30th day after the insertion 95% of the inserted catheters work successfully, on the 60th day – 90%, on 180th day – 67%, at the end of the first year – 39% and at the end of the second year – 16%.

We ascertained statistically significant correlation (p=0.0001) between the diameter of the tunneled catheter and its patency. In our study catheters with diameter 14.5 Fr have the highest patency – on average 422±347 days. The next ones are those with diameter 15 Fr - 409±308 days and the catheters with diameter 13.5 Fr have the lowest patency - 265±248 days. There was no significant difference in the comparison of the patency of catheters with diameter 14.5 and 15 Fr.

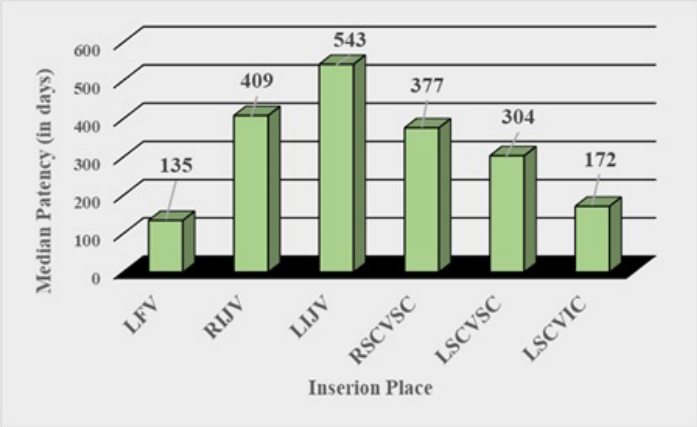

Figure 4: Average patency of the catheter according to the insertion place (LFV – left femoral vein; RIJV/LIJV – right/left internal jugular vein; RSCVCS/LSCVSC – right/left subclavian vein by supraclavicular approach; LSCVIC – left subclavian vein by infraclavicular approach.)

4. Discussion

Our cases of acute complications were 1.2%. They exceed the frequency reported by S. Trerotola et al. [13], who described only 2 (0.8%) cases of pneumothorax among 250 patients. We most often used the supraclavicular approach to the subclavian vein - in 281 (56%) of all inserted catheters. S. Patrick et al. make a literature review of the various methods for supraclavicular approach (2009) and cite literature data according to which the successful catheterization of the vein by the original method of D. Joffa [14] is 84.5-100%, and the frequency of early complications - 0, 0 -4.9%; The "pocket" approach of J. Gorchynski et al. [15] is associated with 90% success and 0.0% complications. The authors conclude: "The

supraclavicular approach to the subclavian vein has more advantages over the infraclavicular approach, unfortunately it is rarely used and the reasons for this are unclear" [16].

The norms of NKF-KDOQI of 2006 recommend that, by using permanent ultrasound control, no more than 1% early complications should be allowed, such as "pneumothorax, air embolism, haemothorax, hemomediastinum and haematomas which requires evacuation" [17]. In our study we did not ascertain any case of such a severe early complication of catheter insertion.

We did not find a large number of publications which depict the frequency of the arrhythmias, as an acute complication, associated with the catheter insertion. T. Vesely shares that "positioning of the tip of the catheter in the right atrium is associated with the appearance of arrhythmias" [18].

The correlation between the acute complications and the insertion place of the catheter is statistically significant ($p<0.05$) and coefficient of Pearson-Brave, $r=0.23$). This one coefficient shows weak positive, directly proportional correlation between the probability for manifestation of early complication and catheter insertion in the right jugular vein. We do not accept the existence of connection between the appearance of acute complication and insertion of the catheters in our research.

The frequency of catheter-associated infections that we found is significantly lower (0.2 cases per 1000 CD) than the frequency quoted by Lisa Milles et al. – 1.1 to 5.5 cases per 1000 CD [19], but it is closer to the data of A. Martín-Peña et al. – 0.34/1000 CD [20].

In 17 cases (74%) of the 23 specified bacterial causes are Gram (+) bacteria and cocci (G (+)) and the in the rest 6 cases (26%) they are Gram (-) bacteria (G (-)). These records coincide with the records of other authors about the frequency of bacterial causes [21, 22, 23].

Catheter thrombosis is the most common reason for catheter dysfunction according to the authoritative research of A. Besarab and R. Pandey and it is the reason behind 75% of the cases of catheter dysfunction after the 90th day [24]. The records from the study of A. Shanaah et al. from 2003 are similar [25]. According to us, the decrease of the frequency of this complication depends on our cares for TC: to be washed out very well before and after the procedure, the blood flow to consists of more than 330-350 ml/min during the dialysis session and TC to be filled up with solution that contains heparin. We use solution which contains 1250 units/ml heparin.

In 12 patients (2.3%) we found mechanical damage of the catheters, which are the reason for the catheter dysfunction and they are not stated in most studies. These damages can be: bending of the external part of the catheter, detachment of fixative sutures, leading to the self-removal of the catheter, rupture of the corpus of the catheter with blood loss or late migration of the tip of the catheter.

The average patency of one catheter in our study was 388±330 CD. Despite some possible difficulties during the insertion, the catheters placed in the left side show better patency. In our opinion, the explanation of this phenomenon owes to the fact that in the majority of people the right hand is dominant, and they mostly speak and eat turned to the right, which leads to local contamination of the zone around the catheter.

F. Quarello et al. conclude their 10-year experience in their research from 2006, reporting 1-year patency 86% and 2-year patency 79% [26]. M. Zafarghandi et al. (2013) report experience on a small number - 40 tunneled catheters, concluding that the catheters, inserted in the subclavian vein by infraclavicular approach have almost twice higher patency than the catheters, inserted in the internal jugular vein – respectively 440±31 and 296±39 days [27]. C. Schroders et al. (2013) report their experience on 1018 tunneled catheters, which have average patency of 150 days, as 25 % of them function well even after the 180th day after the insertion [28]. K. Burton et al. (2012) report their own experience on tunneled catheters, inserted in the femoral vein, which have patency of 30, 60, 90, 180 days respectively 53,8%, 45,4%, 32,1% and 27,1%. Similar results have also been reported by other authors [29]. E. Bour et al. (1990) report average patency of tunneled catheters 84 days, as they notify that in 20% of their patients all the 40 cases of catheter thrombosis have been observed and they conclude that the right positioning under X-ray control is a cornerstone for good work [30]. R. Cetinkaya et al. (2003) report average patency of tunneled catheters 289 days [31].

Michael Allon has published data (2007) about the primary patency of arteriovenous prosthesis of 70-85% on the third month and 47 to 63% on the sixth month, whereas according to the same author, the native arteriovenous anastomosis does not mature adequately in 20 to 50% of the cases and a new surgical intervention is needed [32].

5. Conclusion

According to the data from our study, we ascertained that the insertion of tunneled catheters, used in hemodialysis can be performed successfully by nephrologists. We did not find correlation between chronic complications and the insertion place of the catheter but we ascertained statistically significant correlation between its diameter, insertion it the left half of the thoracic part of the body and better primary patency.

Following the guidelines for good clinical practice during the procedure of insertion and exploitation of tunneled catheters, used for hemodialysis treatment, decreases the risk of acute and chronic complications.

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