



Central venous catheters in hemodialysis: to accept recommendations or to stick to own experience

Centralni venski kateteri za hemodijalizu: da li prihvatiti preporuke ili se oslanjati na vlastita iskustva

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Abstract

Background/Aim. Hemodialysis catheter, as an integral part of hemodialysis, is a catheter placed into the jugular, subclavian and femoral vein. The most common catheter-related complications are infections and thrombosis. The aim of the study was to analyze the prevalence of complications associated with differently inserted central-vein catheters for hemodialysis. **Methods.** The study was organized as a prospective examination during the period from December 2003 to November 2006, and included all patients who needed an active deputation by hemodialysis, hospitalized at the Clinical Center Kragujevac. The subject of the study were 464 central-vein catheters inserted during the mentioned period and there were recorded all complications related to the placement and usage of catheters. **Results.** The largest percent of inserted catheters was into the femoral vein – 403 (86.8%), significantly less into the jugular vein – 42 (9.2%), while into the subclavian vein there were placed only 19 catheters (4%). The average of femoral catheter functioning was 17 catheter days, in jugular catheters it was 17.3 days while the subclavian catheters had an average rate of functioning of 25.9 catheter days; there was found a statistically significant difference regarding the duration of functioning ($p = 0.03$). By microbe colonization of smear culture of the skin at the catheter insertion site, in clinically present suspicion of catheter infection, there was obtained a positive finding in 5.5% of catheters placed into the femoral vein and 7.1% of catheters in-

stilled into the jugular vein, of which *Staphylococcus aureus* was the most important bacterial type, without statistically significant difference ($p = 0.51$). Haemoculture, done when there was a suspicion of bacteremia, was positive in 3.7% of the patients with femoral and 4.8% with jugular catheters; *Staphylococcus aureus* was the most common bacteria type, but there was no statistically significant difference ($p = 0.65$). Colonizing the smears of the cut catheter tops, there was found a positive finding in 8.9% of femoral and 4.7% of jugular catheters in which the mentioned type of staphylococcal bacteria was prevalent, without statistically significant difference ($p = 0.82$). In 77% of femoral, 71.4% of jugular and 68.4% of subclavian catheters, there were no complications associated with insertion and manipulation of catheters for hemodialysis and the difference was at the limits of statistical significance ($p = 0.06$). **Conclusion.** Unconvincing rate of infections and a smaller percent of serious complications associated with the placement and use of central vein catheters instilled into the femoral vein, indicate that personal experience is sufficient recommendation to convince us that femoral vein does not represent a region with an increased risk for insertion of hemodialysis catheters.

Key words:

renal dialysis; catheterization, central venous; risk assessment; bacterial infections; diagnosis; bacteriological techniques; femoral vein; subclavian vein; jugular veins.

Apstrakt

Uvod/Cilj. Hemodijalizni kateteri integralni su deo hemodijalize, a najčešće komplikacije koje prate njihovo plasiranje i upotrebu su infekcija i tromboza. Cilj rada bio je analiza prevalencije komplikacija različito pozicioniranih centralnih venskih katetera za hemodijalizu. **Metode.** Studijom su obuhvaćeni bolesnici čije lečenje je zahtevalo ak-

tivnu depuraciju hemodijalizama, hospitalizovani u Kliničkom centru u Kragujevcu od decembra 2003. do novembra 2006. godine. Predmet istraživanja bila su 464 centralnih venskih katetera plasirana u navedenom periodu, a evidentirane su sve komplikacije koje su pratile njihovo plasiranje i upotrebu. **Rezultati.** Najviše katetera bilo je i plasirano u venu *femoralis* – 86,8% katetera, a njihovo prosečno vreme funkcionisanja iznosilo je 17 kateter dana. U

jugularnu venu plasirano je 9,2% katetera, sa prosečnim vremenom funkcionisanja od 17,3 dana, a u venu supklaviju 42% katetera sa prosečnim vremenom funkcionisanja od 25,9 dana. Utvrđena je statistički značajna razlika ($p = 0,03$) u odnosu na dužinu funkcionisanja katetera. Mikrobiološkim ispitivanjem – zasejavanjem kulture briseva kože ulaznog mesta katetera, dobijen je pozitivan nalaz kod 5,5% plasiranih katetera u femoralnu venu i kod 7,1% instiliranih katetera u jugularnu venu, bez statistički značajne razlike ($p = 0,51$). Hemokultura kod sumnje na bakteriemiju bila je pozitivna kod 3,7% bolesnika sa femoralnim i kod 4,8% sa jugularnim kateterima, bez statistički značajne razlike ($p = 0,65$). Zasejavanjem briseva sa vrhova odstranjenih katetera dobijen je pozitivan nalaz sa 8,9% femoralnih i 4,7% jugularnih katetera; statistički značajna razlika između ispitivanih grupa nije postojala ($p = 0,82$).

Kod 77,9% femoralnih, 71,4% jugularnih i 68,4% subklavija katetera nije bilo komplikacija koje prate plasiranje i manipulaciju katetera za hemodijalizu, a razlika je bila na granici statističke značajnosti ($p = 0,06$). **Zaključak.** Nedovoljno ubedljiva stopa infekcije i manji procenat ozbiljnih komplikacija koje prate plasiranje i upotrebu centralnih venskih katetera plasiranih u femoralnu venu upućuje na to da je sopstveno iskustvo dovoljna preporuka koja potvrđuje da femoralna vena ne predstavlja regiju sa povećanim rizikom za plasiranje katetera za hemodijalizu.

Ključne reči:
hemodijaliza; kateterizacija, centralna, venska; rizik, procena; infekcija, bakterijska; dijagnoza; bakteriološke tehnike; v. femoralis; v. subclavia; vv. jugulares

Introduction

Hemodialysis catheters are an integral part of hemodialysis, as a method for direct access to vascular system in case of an urgent deputation, and they represent a "bridge" to a permanent form of vascular access^{1,2}.

The choice of the site for catheter placement is caused by certain topographic characteristics of available places of large veins such as different skin changes, anatomic varieties of the neck, chest and femoral region, bone and tissue malformation. There are general recommendations that the right jugular vein is an ideal place for acute vascular access for hemodialysis because of the fact that, thanks to its vertical position, it decreases the risk for catheter malposition and possible central venous obstructions³⁻⁵. Vascular access to inguinal region avoids a possible risk for pneumothorax, haemothorax, cardiac arrhythmia and pericardial tamponade. Compared to cannulations of proximal veins, frequency of catheter-related infections and bacteriemias of femoral regions are significantly higher⁵. Cannulation of subclavian vein increases the risk for stenosis of access vein and that compromises the creation of permanent vascular access on that extremity³.

The most common complications related to the usage of hemodialysis catheters are infections present in 20% of the placed catheters and thrombosis which is responsible for 31% of non-functioning catheters. The other complications associated with catheter placement are hemothorax, pneumothorax and air embolism^{1,5}.

The challenges related to hemodialysis catheters lead one to think about a form of an ideal catheter which would satisfy the following elements: easy placement and easy removing, commercial availability, maximal protection from the infection, preventing the formation of fibrin level within the catheter lumen, blood flow higher than 400 ml/min, duration and persistence of material, comfort and acceptability for the patients. Regarding the fact that there is no ideal hemodialysis catheter, certainly not at first sight, from the patients' point of view catheters are the best form of vascular access because they avoid an unpleasant veinpunction three times a week¹. The aim of this study was to identify the

character of complications associated to placement and usage of catheters with hemodialysis catheter insertion sites.

Methods

The study was designed as a prospective examination and involved all patients hospitalized at Clinical Center Kragujevac whose treatment required an active deputation by hemodialysis, using central venous catheters, during the period from December 2003 to November 2006. The subjects of the study were 464 catheters placed within the period of examination.

Clinical data included: place of cannulation of large veins, sex structure of examined patients and duration of functioning catheters. According to the clinical image, there was skin smear colonized from the insertion site, as well as the hemoculture and smear of the tip of a catheter, after its extirpation.

Complications related to the placement and use of a catheter were arterial punctions, vein stenosis, thrombophlebitis, malfunctions and mechanical damage of catheter. The other data were on the outcome of hospitalizations and on the type of chronic vascular access in the patients who continued with the treatment by some form of chronic deputation. All catheters were placed by Seldinger's method, without ultrasound guided puncture and recorded until the moment when the catheter was removed for the different reasons such as no need for further dialysis (acute renal insufficiency), changing the current treatment for chronic dialysis or lethal outcome. All catheters were made of polyurethane, created as two-lumen and non-tunneled, BALTON[®], 11F x 20 cm.

Descriptive statistical methods were used for analysis and hypotheses were tested by χ^2 test, ANOVA and t test. The significance level of statistical hypothesis test was 0.05.

Results

During the period from December 2003 to November 2006 at Clinical Center "Kragujevac" there were inserted 464 central venous catheters for active deputation by hemodialysis. Of the total number of the placed catheters, most of

them were inserted into the femoral vein – 403 (86.8%), significantly smaller number into the jugular vein – 42 (9.1%), and much smaller number into the subclavian vein – 19 (4.1%) (Figure 1). It is obvious that intervention radiologists,

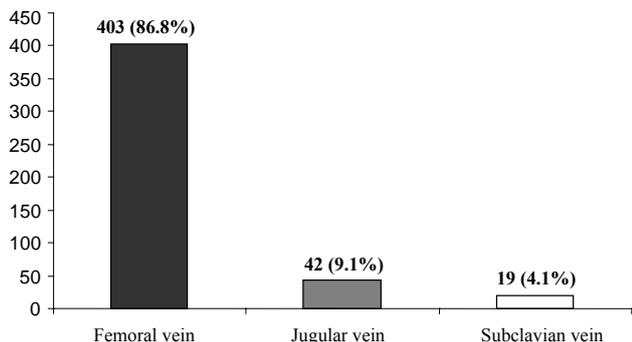


Fig. 1 – Comparison of distribution of patients in relation to the catheter insertion site

working according to organization of the job, place central venous catheters into the femoral vein, as acute vascular access for all patients requiring active depuration. In case of the presence of certain technical problems, hemodialysis catheter insertion was performed by anesthesiologist who uses upper parts (jugular and subclavian vein) for instillation.

Figure 2 shows the sex structure of the examined patients with implanted catheters, with no significantly higher number of male patients in all three groups of the patients.

The average functioning of catheters inserted into the femoral vein was 17 days; the same situation was with the jugular vein, while the patients with subclavian catheters had functioning catheters during the period of 26 days (Table 1). Regarding the duration of functioning catheter, in relation to the catheter site, there was a statistically significant difference ($p = 0.03$).

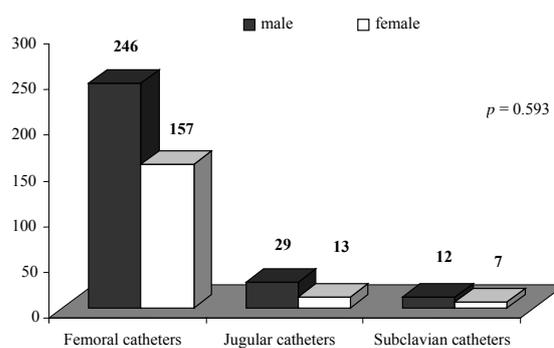


Fig. 2 – Sex structure of the examined patients

In case of potential catheter infection, there was insisted on microbiological verification of skin at the insertion site. Of total number of patients with central venous catheter placed into the femoral vein, with the present signs of infection, 5.5% had positive bacteriological finding with predominant bacteria from *Staphylococcus* group. In 7.1% of the taken smears from jugular catheter insertion site the positive bacteriological finding was observed, with all bacteria from *Staphylococcus* group.

There was no statistically significant difference in differently placed central venous catheters, compared with the reported bacterial flora, after the colonization of smears of insertion site; $\chi^2 = 1.34$; degree of freedom (DF) = 2; $p = 0.51$ (Table 2).

In the patients with implanted catheters who had symptoms and signs of generalized infection, hemoculture was determined. The rate of positive findings was 4.8% in the patients with catheter inserted into the jugular vein and 3.7% in the patients with catheters placed into the femoral vein; the majority of bacteria were from *Staphylococcus* group. None of the patients with subclavian catheters had

Table 1

Influence of catheter site on the duration of functioning catheter (days)

Catheter site	n	Mean	SD	Minimum	Maximum
Femoral vein	383	17.0	12.9	1	83
Jugular vein	36	17.3	14.9	1	59
Subclavian vein	16	25.9	12.9	1	43
Total	435	17.4	13.2	1	83

$\chi^2 = 3.53$; DF = 2.432; $p = 0.03$
 Functioning is statistically significantly longer in catheters placed into the subclavian vein compared with femoral ($p = 0,008$) and jugular ($p = 0,029$) catheters.

Table 2

Microbiological characteristics of insertion site of cannulated veins

Bacterial flora	Insertion site						Total	
	femoral vein		jugular vein		subclavian vein		n	%
	n	%	n	%	n	%		
<i>Staphylococcus spp.</i>	18	4.5	3	7.1	0	0.0	21	4.5
<i>Escherichia coli</i>	2	0.5	0	0.0	0	0.0	2	0.4
<i>Corynebacterium spp.</i>	2	0.5	0	0.0	0	0.0	2	0.4
Total	22	5.5	3	7.1	0	0	25	5.4
No clinical symptoms of catheter-related infection	381	94.5	39	92.9	19	100.0	439	94.6
Total	403	100.0	42	100.0	19	100.0	464	100.0

$\chi^2 = 1.34$; DF = 2; $p = 0.51$

symptoms of sepsis. Regarding the frequency of microbiological findings of hemoculture, there was no statistically significant difference in patients with differently placed central venous catheters, ($\chi^2 = 0.87$; DF = 2; $p = 0.65$) (Table 3).

Regarding the microbiological identification of tips of removed catheters, in the patients with symptoms of infection there was confirmed the form of "dirty" place of femoral region because the greatest number of positive findings was in central venous catheters inserted into the femoral vein (8.9%), compared to the jugular vein (4.7%). However, there was no statistically significant difference among differently placed catheters, regarding the reported bacterial flora of tips of removed catheters ($\chi^2 = 0.39$; DF = 2; $p = 0.82$) (Table 4).

The most common accidental arterial punctions occurred during the catheter insertion into the subclavian vein (15.8%), vein stenosis was found in 10.5% of the subclavian catheters, while the malfunction of central venous catheters was most often in the jugular veins (23.8%). Mechanical damage of catheters was almost the same both in cannulation of jugular and femoral veins, and thrombophlebitis was reported in 3.7% of the catheters installed into the femoral vein. The difference in complications of central venous catheterization in the examined population of patients was at the limits of statistical significance, ($\chi^2 = 1.71$; DF = 2; $p = 0.06$) (Table 5).

Table 3

Bacterial flora	Insertion site						Total	
	femoral vein		jugular vein		subclavian vein		n	%
	n	%	n	%	n	%		
<i>Staphylococcus spp.</i>	10	2.5	1	2.4	0	0.0	11	2.4
<i>Escherichia coli</i>	1	0.2	0	0.0	0	0.0	1	0.2
<i>Pseudomonas spp.</i>	1	0.2	0	0.0	0	0.0	1	0.2
<i>Corynebacterium spp.</i>	1	0.2	0	0.0	0	0.0	1	0.2
<i>Klebsiella spp.</i>	2	0.5	0	0.0	0	0.0	2	0.4
<i>Diplococcus spp.</i>	0	0.0	1	2.4	0	0.0	1	0.2
Total	15	3.7	2	4.8	0	0	17	3.6
No clinical symptoms of catheter-related infection	388	96.3	40	95.2	19	100.0	447	96.4
Total	403	100.0	42	100.0	19	100.0	464	100.0

$$\chi^2 = 1.87; DF = 2; p = 0.65$$

Table 4

Microbiological characteristics of the tips of removed catheters at the insertion site of cannulated veins

Bacterial flora	Insertion site						Total	
	femoral vein		jugular vein		subclavian vein		n	%
	n	%	n	%	n	%		
<i>Staphylococcus spp.</i>	10	2.5	1	2.4	0	0.0	11	2.4
<i>Streptococcus spp.</i>	10	2.5	0	0.0	0	0.0	10	2.2
<i>Escherichia coli</i>	5	1.2	0	0.0	0	0.0	5	1.1
<i>Pseudomonas spp.</i>	3	0.7	0	0.0	0	0.0	3	0.6
<i>Corynebacterium spp.</i>	2	0.7	0	0.0	0	0.0	2	0.4
<i>Klebsiella spp.</i>	4	1.0	0	0.0	0	0.0	4	0.9
<i>Proteus spp.</i>	1	0.2	0	0.0	0	0.0	1	0.2
<i>Enterococcus spp.</i>	0	0.0	1	2.4	0	0.0	1	0.2
<i>Candida spp.</i>	1	0.2	0	0.0	0	0.0	1	0.2
Total	36	8.9	2	4.7	0	0.0	38	8.2
No clinical symptoms of catheter-related infection	367	91.1	40	95.3	19	100.0	426	91.8
Total	403	100.0	42	100.0	19	100.0	464	100.0

$$\chi^2 = 0.39; DF = 2; p = 0.82$$

Table 5

Distribution of complications related to insertion site of central venous catheters

Insertion site	Complications						Total
	not found	thrombophlebitis	reduced catheter-functioning	mechanical damage	arterial puncture	vein stenosis	
Femoral vein [n (%)]	314 (77.9)	15 (3.7)	63 (15.6)	10 (2.5)	1 (0.2)	0 (0.0)	403 (100.0)
Jugular vein [n (%)]	30 (71.4)	0 (0.0)	10 (23.8)	1 (2.4)	1 (2.4)	0 (0.0)	42 (100.0)
Subclavia vein [n (%)]	13 (68.4)	0 (0.0)	1 (5.3)	0 (0.0)	3 (15.8)	2 (10.5)	19 (100.0)
Total [n (%)]	357 (76.9)	15 (3.2)	74 (15.9)	11 (2.4)	5 (1.1)	2 (0.4)	464 (100.0)

$$\chi^2 = 1.71; DF = 2; p = 0.06$$

Note: The utmost number of complications is reported in femoral catheters

Discussion

After arteriovenous shunts which are the part of history, central venous catheters are the first choice of vascular access for patients who need urgent hemodialysis. They represent an ideal method to include the patients into a program of an active treatment by hemodialysis, having a temporary character².

The aim of this study was neither to discuss nor to deny familiar facts about almost uniform acceptance of jugular vein as an insertion site of hemodialysis catheters. There was also no increased rate of subclavian vein stenosis after its cannulation, nor a form of "dirty" place for femoral vein^{3,6}.

The purpose of this study was to show different experiences when the femoral vein was used as an insertion site of central venous catheters. Pecorari⁷ shows his positive experience about the placement of Tesio catheters into the femoral vein, as a model of permanent vascular access. Kaneda et al.⁸ used the femoral vein for maintenance of chronic hemodialysis, by repeated vein punctions with the average survival of this vascular access 4.99 ± 3.42 years. The percentage of prevalence of femoral catheters in our study is in total agreement with the great experience of Ončevski et al.⁹ regarding the material including 4 694 catheters.

In our study, there was no statistically significant difference in sex structure of patients compared to differently placed hemodialysis catheters, but even in the literature there is no consensus about the influence of sex structure on survival and the complications related to the placement and use of central venous catheters for hemodialysis but there was the important influence of age structure and other comorbid states on the increase in morbidity structures of patients with inserted catheters^{1,6}.

The recommendations concerning acute vascular accesses were given in the form of satisfying of generally known principles which disable complications related to the placement and usage of central venous catheters for hemodialysis. The practice and tendency to femoral catheters in Clinical Center Kragujevac cause different attitudes and experiences regarding the suggested standards. The guidelines Dialysis Outcomes Quality Initiative (DOQI) which recommend femoral catheter insertion only in hospitalized patients, and not longer than 5 days⁵, sound inconclusively compared to the results of our study where the femoral vein represents a predominant place for insertion of central venous catheters. The maximal duration of functioning of a catheter placed into the femoral vein was 83 days, with the average survival of 17 days, what is in an absolute disagreement with many authors and DOQI guidelines recommendations^{1,3-6}, except with the previously mentioned study of Ončevski et al.⁹.

The use of central venous catheters is associated with adverse events that are both hazardous to patients and expensive to treat. Mechanical complications are reported to occur in 5–19% of patients, infectious complications in 5–26%, and thrombotic complications in 2–26%¹⁰. Infections, as the most common central venous catheter-related complications, limit their function, increase morbidity and mortality and make the treatment more expensive. The highest number of

catheter-related infections, which include local infection of exiting side and tips of catheters, and systemic bacteremia, were caused by microorganisms settled in skin. Mild symptoms of catheter-related infection include malaise and nausea, in the setting of a normal catheter exit site or tunnel, on physical exam. More severe symptoms of catheter-related bacteremia include high fever with rigors, hypotension, vomiting and changes in mental status. In this situation patients will often develop rigors and a pyrexia on flushing or using the catheter. These are only cultures organisms from the outside of the catheter and require removal of the catheter¹¹. The approach to an acute vascular access is directed by the use of modern materials, protective antibacterial layer and medical staff correctly educated to deal with catheters^{1,3,12-14}. Minimizing catheter-related bacteremia requires the dialysis staff to follow aseptic technique¹⁴, including washing hands, wearing clean gloves, and minimizing the duration of air exposure of the catheter lumens. Catheter hubs should be soaked with povidone-iodine before connection and disconnection of the catheter from the dialysis tubing. Both the dialysis staff and the patient should wear masks when the catheter lumen is exposed. There does not seem to be a difference between application of gauze and transparent dressing to the exit site between dialysis sessions¹⁵.

The infection rate is different regarding the insertion site and all infections could be fatal. There is an almost agreeable opinion in the literature about the femoral region as a place with greatest risk for infections^{1,3,5,13,16,17}. Microbiological analysis of the skin smear colonized from the insertion site to point out positive findings in 3.7% catheter in the femoral vein and 4.8% catheter in the jugular vein. The data obtained in our study showing that 94% of catheters inserted into the femoral vein had no symptoms of insertion site infection compared to 93% of jugular catheters, are not in agreement with the literature, except with the study of Ončevski et al.⁹. The similar relation was also with symptoms of generalized sepsis. Maybe the only data of our study that can fit into the story about "dirty" femoral region, are the data on microbiological verification of smears of the tips of the removed catheters, where the number of colonizing the smears of the cut catheter is almost two times higher in relation to central-venous catheter placed in the jugular vein. And about the types of bacterium, our results are not different in relation to examination from another studies where also bacteria from the group of *Staphylococcus* were found. No finding of positive colonizing the smears place from the top of removed catheter and hemoculture at catheters placed in vein subclavia was present what is agreement with informations from available clinical practice, too¹⁰.

Factors contributing to infection of central vein catheters could be classified as host-related factors (impaired host immunity, poor personal hygiene, occlusive dressing, older age, diabetes mellitus, *Staphylococcus aureus* nasal carriage, recent hospitalization, high cumulative dose of intravenous iron), catheter-related factors (site of insertion, increased duration of catheter use, history of bacteremia, colonization of catheter tip and cutaneous tract with skin flora, catheter lumen contamination, hematogenous seeding of the catheter

from another infectious source, contamination of the lumen with infusate lack of aseptic precautions during catheter insertion), pathogen-related factors (biofilm formation, resistance to antibiotic therapy, bacterial virulence, *Staphylococcus aureus* nasal carriage, contiguous infection), hemodialysis procedure-related factors (contamination of dialysate or equipment, inadequate water treatment, dialyzer reuse)¹⁸.

Ipsilateral lower extremity deep vein thrombosis occurs commonly after the placement and long benefit of a femoral dialysis catheter according to our study. The risk of subclinical femoral vein thrombosis associated with long-term access to the femoral vein has been reported to be as high as 8%, while in our examinees this percentage was 3.7%. Catheter-directed thrombolytic therapy with or without percutaneous mechanical thrombectomy is the treatment of choice. Arterial puncture is more common in femoral catheters when are venous stenosis is present in the subclavian vein^{1,3-7,18}. In our study, the insertion of central vein catheters included the use of procedures and methods of operative surgery, what was especially important for reduced rate of expected complications in femoral catheters. However, regardless the location

of catheter site and material which the catheter is made of, the most important factor in prevention and treatment of all complications that appear during manipulations of hemodialysis catheters is a continuous education of all medical staff that are in contact with patients through inserting central vein catheters for hemodialysis.

Considering the limitations of this study, in regard to proportionally lower number of jugular and subclavian catheters compared to femoral ones, we are sure, however, that one should follow personal practical experiences which indicate that there are no serious complications and that femoral region is not a risk factor for insertion of central venous catheters.

Conclusion

A routine placement by intervention radiologists, the lower percentage of serious complications and unconvincing rate of infections recommend the femoral vein to be the choice for hemodialysis catheter insertion in our patients, in spite of the official attitude and established opinions.

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