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Safety and functionality of transhepatic hemodialysis catheters in chronic hemodialysis patients

Bekir Şanal
Ömer Fatih Nas
Nurullah Doğan
Mehmet Korkmaz
Kadir Hacıkurt
Abdulmecid Yıldız
İrem İris Kan Aytaç
Bahattin Hakyemez
Cüneyt Erdoğan

PURPOSE
We aimed to investigate the safety and functionality of tunneled transhepatic hemodialysis catheters in chronic hemodialysis patients.

METHODS
Thirty-eight patients (20 women aged 56±10 years and 18 men aged 61±11 years) with transhepatic tunneled hemodialysis catheters were evaluated. The date of the first transhepatic catheterization, indications, procedure details, functional time periods of catheters, reasons for the removal or revision of catheters, catheter-related complications, and current conditions of patients were retrospectively analyzed.

RESULTS
A total of 69 catheters were properly placed in all patients (100% technical success) under imaging guidance during the 91-month follow-up period. The functionality of 35 catheters could not be evaluated: five catheters were removed because of noncomplication related reasons (surgical fistulas were opened in two cases [2/35, 5.7%], transplantation was performed in three cases [3/35, 8.6%]), 18 patients died while their catheters were functional (18/35, 51.4%), and 12 catheters were still functional at the time of the study (12/35, 34.3%). The functionality of catheters was evaluated the remaining 34 catheters that necessitated revision because of complications. Furthermore, only half of the catheters were functional on day 136 when evaluated using Kaplan-Meier analysis. The four main complications were thrombosis (16/34, 47%; complication rate of 0.37 days in 100 catheters), infection (8/34, 23.5%; 0.18 days in 100 catheters), migration (8/34, 23.5%; 0.18 days in 100 catheters), and kinking (2/34, 6%; 0.04 days in 100 catheters).

CONCLUSION
Transhepatic venous catheterization is a safe and functional alternative route in chronic hemodialysis patients without an accessible central venou route. The procedure can be performed with high technical success and low complication rates under imaging guidance.

The main central venous routes used in chronic hemodialysis patients with insufficient arteriovenous (AV) fistulas and graft failure are the jugular, subclavian, and femoral veins. Repeated interventions and chronic thrombosis, stenosis, and occlusions secondary to long-term catheterizations can make the use of these veins impossible over years (1, 2). Alternative routes are lifesaving in these cases, and the principle routes are the translumbar inferior vena cava (IVC) and transhepatic veins (2–5).

The use of the translumbar route is more widespread, its efficiency and safety are well known, and the experience in using this method has already been reported in the literature (5–8). Hepatic vein and IVC catheterization through the transhepatic route is a comparatively more up-to-date method than the one through the translumbar route, and there is only limited experience in using this method. Its success and complication rates were first described by Po et al. (9) in 1994 in one case, and this method was further scrutinized in three retrospective studies comprising 12, 16, and 22 adult patients in the following years (2–4).

The aim of this retrospective study was to investigate the safety and functionality of transhepatic hemodialysis catheters in a series of 38 patients.

Methods

Patients

The study was approved by the local ethics committee. Thirty-eight transhepatic tunneled hemodialysis catheter implanted patients (mean age 58±11 years; range, 23–80 years;

From the Department of Radiology (B.S. ✉ *bekir.sanal@gmail.com*, M.K.), Dumlupınar University School of Medicine, Kütahya, Turkey; the Departments of Radiology (Ö.F.N., K.H., B.H., C.E.) and Cardiovascular Surgery (İ.İ.K.A.), the Division of Nephrology, the Department of Internal Medicine (A.Y.), Uludağ University School of Medicine, Bursa, Turkey; Radiology Clinic (N.D.), Private Bahar Hospital, Bursa, Turkey.

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comprising 20 females aged 56±10 years and 18 males aged 61±11 years) from two different centers were retrospectively reviewed between June 2007 and December 2014. All patients had chronic renal insufficiency and a history of previous multiple peripheral venous intervention and catheterization. The main indication for the transhepatic approach was chronic occlusion secondary to multiple interventions in peripheral veins. One of these peripheral ways was accessible in nine patients, but these were preserved for potential AV fistula/graft intervention. The date of transhepatic catheterization, the reasons for the removal or revision of catheters, the functional time periods of the initially implanted or revised catheters, and catheter-related complications were retrospectively analyzed.

Procedure

The hematologic and coagulation parameters of patients were confirmed to be within normal ranges before each intervention (international normalized ratio [INR] <1.5 and platelet count >75000/mm^3). All patients were informed about the procedure and informed consent was obtained. Procedures were executed while patients were conscious and sedated under the control of an anesthesia team (applying midazolam 0.03 mg/kg intravenous [i.v.] and/or fentanyl 1 µg/kg i.v. and/or ketamine 1 mg/kg i.v. and/or propofol 3–5 mg/kg i.v. and/or pethidine 1 mg/kg intramuscular). Each procedure was performed by an experienced interventional radiologist. Following surgical cleansing of the team, surgical skin cleansing was performed on the right thoracoabdominal area by applying antiseptic solution at least three times (povidone-iodine 10%, Batticon, Adeka). Imaging guidance was made by ultrasound (US) with a sterile coated probe (Aplio 50, Toshiba and Vivid-e, GE Healthcare) and by angio-fluoroscopy (AXIOM Artis Biplane Angiosuite, Siemens and Artis Zee, Siemens and AXIOM Sensis, Siemens).

Main points

- Transhepatic venous catheterization is a safe and practical alternative route in chronic hemodialysis patients without an accessible central venous route.
- With effective use of imaging modalities, transhepatic venous catheterization has high technical success and low complication rates in experienced hands.
- It can be used transiently in cases in which AV fistula-graft or renal transplantation is planned, and permanently in patients with low life expectancy or those with no chance to switch to permanent treatments.

Transhepatic intervention was made through the right lobe in 34 patients and the left lobe in four patients. Access was made through the midaxillary line level on the right and the subxyphoid level on the left lobe. Local anesthesia was made with subcutaneous 2% prilocaine 10 mL injection (Citanest, AstraZeneca). The appropriate hepatic vein was chosen by US guidance and access to this vein was made through smaller veins draining into the vein using a 21G Chiba needle. Branches of the portal vein were avoided to be punched while accessing the hepatic vein. The location of the needle was confirmed by contrast media injection under fluoroscopy. The hepatic segment of the IVC and then the right atrium were reached under fluoroscopy. The distance between the entrance point of the microwire and the right atrium was measured by bending the microwire at the site of the entrance to the skin. The length of the tunneled catheter was determined based on this distance. The lengths of the catheters ranged between 23/28 and 32/36, and these were hemodialysis catheters with two tips (SplitCath III, Medcomp; HemoSplit, Bard; Tesio twin catheter, Medcomp; and Mahurkar). A coaxial micropuncture sheath (Accustick II Introducer System, Boston Scientific; POSI-STICK®, UreSil) was advanced through the microwire, and the wire in the sheath was exchanged with a 0.035-inch Amplatz Super Stiff guidewire (Boston Scientific), which was present in the tunneled catheter set. The entrance site incision was widened to 1.5 cm after placing the wire. The dialysis catheter was passed through a dilatator-sheath system placed through the wire after widening the entrance site with a dilatator. An incision was made 2–4 cm anteroinferior to the skin access site for the tunnel and then the catheter was tunneled subcutaneously with the help of a tunneling device. The tunneled catheter was advanced through the sheath system and the sheath was then removed. The incision was closed with subcuticular suturing and steristrips (3M). The catheters were washed with heparinized water and the position of the catheter was confirmed with fluoroscopy. The tip of the catheter was in the IVC in five patients on the fluoroscopic images, in the superior vena cava (SVC) in one patient, and in the right atrium in 32 patients (Fig. 1).

Patients were transferred to the angiography suite in case of an insufficiency in flow during the hemodialysis. Patency of the catheters was evaluated by aspirating the blood, by contrast media administration and monitoring under fluoroscopy, or by washing with heparinized saline. The catheter was replaced through the same tract if thrombosis (or fibrin sheath), kinking, or migration was present. Furthermore, it was replaced through the same tract if there was concomitant bacteremia or sepsis (replaced after two days in this condition) without entrance site infection or through a different tract if there was entrance site infection. Catheter revision was made through long stiff wires under the same conditions and under fluoroscopy guidance.

Definitions

All the terms used in the study were defined in light of the "Reporting Standards for Central Venous Access" definitions of SIR (10). Accordingly, throughout this article we use certain defined terms and their meanings are as follows: *Tunneled catheter:* central venous access that travels through a subcutaneous tract before entering the target vein; *Technical success:* introduction into the venous system with the tip positioned in the preferred location and with adequate catheter function (300 mL/min); *Device failure:* any limitation in catheter function despite a technically successful placement. Device failure includes thrombosis, migration, kinking, and infection; *Exit site infection:* erythema and induration within a 2 cm radius from the catheter exit site with no signs of bacteremia; *Complication:* any condition altering catheter function that requires additional treatment. Complications were defined as minor if less than 24 hours hospitalization was required after the procedure and major if more than 24 hours hospitalization was required; *Primary (initial) device service interval*: the number of catheter-days from initial placement until removal; *Secondary (revised) device service interval*: the number of catheter-days after device replacement using the same access site; *Total access site interval*: the sum total catheter-days for a single access site; *Mean time catheter in situ*: the cumulative catheter-days divided by the cumulative number of catheters in the entire study population.

Statistical analysis

Normal distribution of the data was evaluated by using the Shapiro-Wilk test. The de-

scriptive statistics were expressed in terms of the mean with standard deviations in normally distributed data and median with minimum and maximum in data distributed non-normally. The number of catheters that were nonfunctional due to thrombosis, infection, migration, and kinking was determined. The frequency of any catheter-related complication was calculated by dividing the number of catheter with that complication to the total number of catheters. The complication rate (rate per 100 catheter-days) was calculated by dividing the number of catheters with that complication by 4263 days, which is the total cumulative time the catheters were in the patients, and multiplying this by 100. The mean days from insertion to complication was calculated by dividing the development time of that complication to the number of catheters with that complication. The functionality of the catheters was evaluated using Kaplan-Meier analysis on the basis of the number of functional days of the catheter. SPSS v. 20 (IBM Corp.) was used to perform the statistical analysis.

Results

Co-existing conditions of the patients were diabetes (n=10), hypertension (n=21), congestive heart failure (n=1), coronary artery disease (n=13), transient ischemic attack/stroke (n=8), peripheral arterial disease (n=12), cervical cancer (n=2), rectal cancer (n=1), asthma (n=1), and familial Mediterranean fever (n=1). The main indication for using the transhepatic route was the absence of peripheral venous route in 29 patients, frequent catheter-related infections on femoral veins (which was the last venous access route) in two, and preserving the last venous route for surgical fistulization in seven (three subclavian veins, two left femoral veins, and two right femoral veins).

Catheters were properly placed in all 38 patients, and adequate flow was obtained (100% technical success). A total of 69 catheters were implanted in 69 procedures during the 91-month follow-up period. The mean catheter number per patient was 1.81 (1–4 catheters). One catheter was used in 18 cases, two catheters in 11 cases, three catheters in seven cases, and four catheters in two cases. The patency of the catheters was evaluated using Kaplan-Meier analysis, and half of the catheters were functional on day 136 (standard error, 0.086) (Fig. 2).

The functionality of 35 catheters could not be evaluated: five had been removed because of noncomplication related reasons, namely surgical fistulas were opened in two (2/35, 5.7%) and transplantation was performed in three (3/35, 8.6%) patients; 18 patients died while their catheters were functional (18/35, 51.4%); and 12 catheters were still functional in patients at the beginning of the study (12/35, 34.3%). The functionality of catheters was thus evaluated from the other 34 catheters that needed revision because of complications (Table 1). The number of primary catheters was 23 (23/34, 67.6%), while the number of secondary catheters was 11 (11/34, 32.4%), and the cumulative patency time was 4263 days. The primary device service interval was 68 catheter-days (4–405 catheter-days), while the secondary service interval was 199.6±118.8 catheter-days, total access site service interval was 136 catheter-days (8–843 catheter-days), and the time the catheter was in situ was 68 catheter-days (8–405 catheter-days).

Complications occurred in only two cases during or shortly after the procedure. Massive peritoneal hemorrhage occurred shortly after the procedure in the first case. Hemostasis was ensured by emergency laparotomy. In the second case, there was hemorrhage as a leakage after catheter revision, which was stopped with compression. The hemoglobin levels stayed stable and further treatment was not needed in this case. No complication was seen in the other cases during or shortly after the procedure.

The four major complications impairing catheter functionality during the follow-up period of patients were thrombosis, infection, migration, and kinking. The most frequent complication was thrombosis, which was seen in 16 cases (16/34, 47%, 0.37 days in 100 catheters). Thrombosis developed in a catheter in approximately 160.6±119.4 days. While a new catheter was placed through the same tract in 15 of these patients, the new catheter was placed through the patent femoral vein in one patient in whom the femoral vein was useless be-

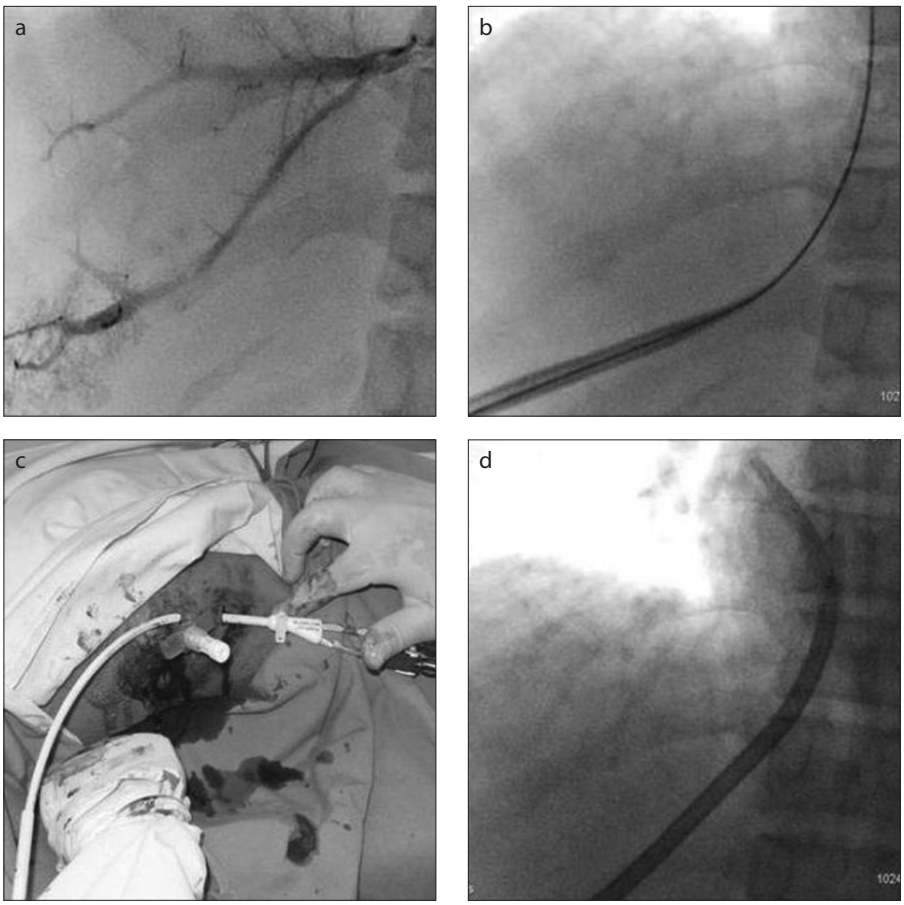

Figure 1. a–d. Transhepatic catheterization. Puncture through a peripheral point of the middle hepatic vein with a fine needle and venography images **(a)**. Panel **(b)** shows entrance tract dilatation. The catheter was tunneled before placing it in the sheath and peeling away the sheath **(c)**. Panel **(d)** shows the tip of the catheter in the right atrium.

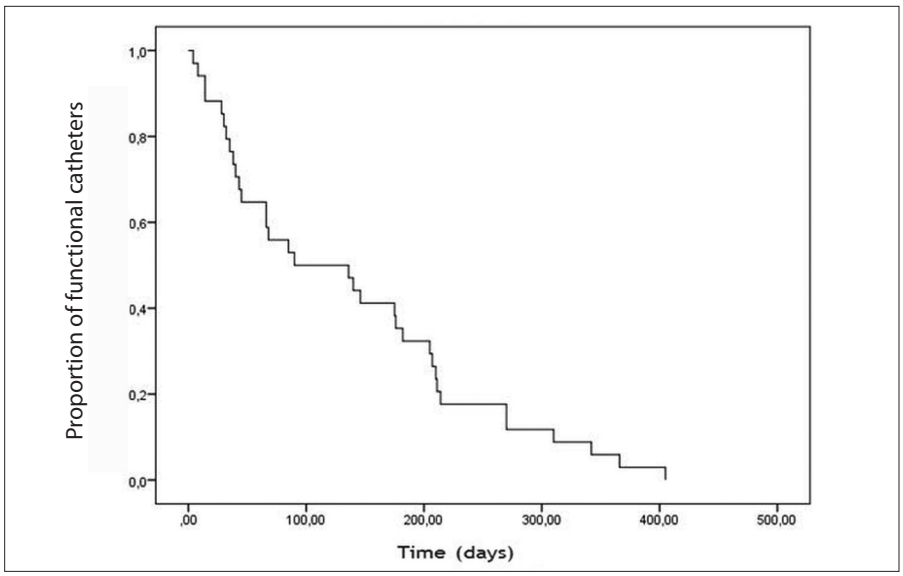

Figure 2. Half of the catheters were functional on day 136 in Kaplan-Meier analysis.

Table 1. Catheters for which the functionality could and could not be evaluated (a total of 69 catheters)

Catheters for which functionality could be evaluated (n=34)	
Primary	23 (67.6)
Secondary	11 (32.4)
Thrombosis	16 (47)
New catheter	15
Femoral dialysis	1
Infection	8 (23.5)
New catheter	7
Femoral dialysis	1
Migration	8 (23.5)
New catheter	7
Translumbar IVC	1
Kinking	2 (6)
New catheter	2
Catheters for which functionality could not be evaluated, n=35	
Patients died while their catheters were functional	18 (51.4)
Patients with still functional catheters	12 (34.3)
Catheter removed because of transplant	3 (8.6)
Catheter removed because of fistula	2 (5.7)

Data are presented as n or n (%).
IVC, inferior vena cava.

cause of a previous catheter-related infection. Infection was seen in eight cases (8/34, 23.5%, 0.18 days in 100 catheters). Blood cultures were positive and there was bacteremia without sepsis in all of these cases. A new catheter was placed through the same tract in four cases. Exit site infection was present in three cases, and a different tract was used for the new catheter in these patients. A new catheter was placed on the patent femoral vein in one patient in whom the femoral vein was useless because of a previous catheter-related infection. Infections occurred on days 43, 66, 85, 140, 146, 176, 211, and 342 (151.1±95.7 days). Migration of the catheter was seen in eight cases (8/34, 23.5%, 0.18 days in 100 catheters). Migrations occurred on days 8, 14, 28, 32, 35, 40, 90, and 214 (median, 33.5 days; range, 8–214 days). Migration was back into the hepatic veins in seven cases and into the peritoneal space in one case. The catheters of seven patients were replaced through the same tract, and IVC catheterization was made with the translumbar approach in one patient. Kinking was seen in two catheters (2/34, 6%, 0.04 days in 100 catheters). Kinking occurred in approximately 216 (66–366) days. Migration and kinking were diagnosed in the case of a functional catheter by observing the localization and shape of the catheter on fluoroscopy (Tables 1, 2).

Discussion

Our study demonstrated that transhepatic venous route is safe and functional when used together with imaging modalities and by experienced hands in chronic hemodialysis patients with inaccessible central venous routes.

The translumbar and transhepatic routes are the main alternative routes in patients who are dependent on chronic hemodialysis and have inaccessible central venous routes. Some researchers (2, 6–8) argue that the transhepatic route is superior to the translumbar route because of certain features: it can be used even in cases with occluded IVC; hemorrhage and migration are less frequent; there is a chance of transhepatic or endovascular embolization in case of hemorrhage; and vascular access in obese patients is easier. Furthermore, translumbar catheter revisions are more difficult because of a risk of retroperitoneal fibrosis. Po et al. (9) applied transhepatic catheterization in an adult patient for the first time in 1994, and since then, it has become an alternative access route in cases that are dependent on chronic hemodialysis and have inaccessible central venous routes. The procedure is technically relatively simple for interventional radiologists and can be successfully applied because of their experiences in biliary drainage and tunneled catheter placement through different peripheral veins (3). However, data about the long-term effectiveness and safety of the procedure are limited (2–4) (Table 3).

The procedure was applied with success in all of our cases. The only remarkable peripro-

Table 2. Catheter-related complications (a total of 34 catheters)

Complication	Total frequency (%)	Rate (per 100 catheter-days)	Mean days from insertion to complication
Thrombosis	16 (47)	0.37	160.6±119.4
Infection	8 (23.5)	0.18	151.1±95.7
Migration	8 (23.5)	0.18	33.5 (8–214)
Kinking	2 (6)	0.04	216 (66–366)

Data are presented as mean±standard deviation or median (range).

Table 3. Study comparison

	Şanal et al. 2016	Younes et al. (4) 2011	Smith et al. (3) 2004	Stavropoulos et al. (2) 2003
No. and sex of patients	38 (18 M, 20 F)	22 (9 M, 13 F)	16 (7 M, 9 F)	12 (7 M, 5 F)
No. catheters	69	127	21	36
Age (years)*	58.0 (23–80)	42.3 (22–70)	51.6 (21–77)	61.0 (40–76)
Most common cause of catheter exchange	Catheter thrombosis	Migration	Catheter thrombosis	Catheter thrombosis
Catheter thrombosis rate (per 100 catheter-days)	0.37	0.18	-	2.40
Infection rate (per 100 catheter-days)	0.18	0.22	2 catheters	0.22
Catheter migration rate (per 100 catheter-days)	0.18	0.39	3 catheters	9 catheters
Primary device service interval (catheter-days)**	68 (4–405)	141.2 (0–565)	64 (1–178)	27
Total access site service interval (catheter-days)**	136 (8–843)	450.3 (12–1.414)	138 (0–599)	70
Patients died with catheters in place, n	18	13	7	5
Removal due to maturation of AV graft, n	2	4	3	-
Functional catheters at the end of the follow-up period, n	12	3	1	-

M, male; F, female; AV, arteriovenous.
*Data are presented as mean (range).
**Data are presented as median (range).

cedural complication was postprocedural massive intraabdominal hemorrhage in one patient, and this was treated with emergency laparotomic hemostasis. This case had primary rectal carcinoma and hemodialysis through the primary catheter for 196 days until his death. The massive hemorrhage was thought to have occurred due to his fragile vascular walls secondary to chemotherapy. A similar complication happened in one patient in the series of Smith et al. (3) comprising 16 patients, where that patient died despite embolization. These two cases suggest that hemorrhage is a serious complication of the procedure and should be taken into consideration. Bleeding parameters may not be restored properly in a patient population with chronic renal insufficiency. Hemorrhage can happen despite the procedure being made under ultrasound guidance and with the main vascular structures spared.

Hemorrhage due to leakage from the tract with a wide lumen can develop when not only advancing the catheter but also when deploying it. Tract embolization was made to prevent hemorrhage after catheter deployment in an initial series concerning transhepatic catheterization (2, 11). However, tract embolization was not performed in two other series (3, 4). Indeed, hemorrhage from the tract is not an expected complication because the direction of flow in hepatic veins is centripetal. We did not perform a tract embolization in any of our cases. External hemorrhage occurred in only one case as a leakage after catheter removal but it could be stopped with compression on follow-up, thus it did not necessitate embolization. We conclude that tract embolization is not mandatory in light of these data but it may be applied in cases with bleeding diathesis in their preoperative period.

The incidence of thrombosis in classical tunneled transjugular catheters placed for hemodialysis is significantly low (0.0103 per 100 days) (12). Thrombosis was the most frequent reason for catheter dysfunction in our series (0.37/100 days), as it was in the series of Stavropoulos et al. (2) and Smith et al. (3). Stavropoulos et al. (2) attributed the high catheter thrombosis incidence in transhepatic route compared with the transjugular and translumbar routes to the lower calibers used with the hepatic veins and shorter transvascular distance that the catheters should pass. Besides agreeing with this opinion, we conclude that the straight course of the catheter to the venous flow in hepatic vein-IVC confluence can affect the generation of thrombosis. The catheter thrombosis rate was reported to be much lower (0.18/100) in the series of Younes et al. (4) compared with other transhepatic series. The possible reason for this could be due to washing the catheter with heparinized saline after each procedure and following the patients with more frequent catheter revisions. These precautions decreased the incidence of thrombosis dramatically.

The second most frequent complication causing catheter revision was infection in our case series (0.18/100). The source of infection was probably catheters in those cases where a source could not be found. Although our infection incidence was lower than in other series, it is obvious that the transjugular approach is more reliable in regard to infection rates (0.007/100) (2–4, 12).

An unexpected position and location of a catheter on fluoroscopy images in cases with dysfunctional catheters is due to migration and kinking. These complications affect both the safety and functionality of catheters. The mean number of days from insertion to complications for catheters in cases with revised catheters due to migration was 33.5 days. This finding shows that migration develops pretty early. The cathe-

ter dropped interestingly to the peritoneal cavity in one case one week after placing it, but after that it was replaced through the same tract. Migration on other cases was back into the hepatic veins. In light of these data and the findings of other researchers, migration is thought to happen in the early period due to respiratory movements and abdominal distension when there is not enough tract fibrosis and in the late period due to the chronic compulsory effects of gravity on the catheter. Furthermore, even though the exact reason is not fully understood, perihepatic fluid accumulation right after the procedure could induce catheter migration into the peritoneal cavity. Migration was the most frequent complication in the series of Younes et al. (4) with 22 patients and 127 catheters; the reason for this could be due to using multiple catheters for short periods.

The transhepatic route was initially suggested to be used for a short time only and transiently until ensuring the maturity of other venous access routes (9). It was used as a transient route in the series of Smith et al. (3) before AV grafting in three patients and subcutaneous port placement in two patients, and in the series of Younes et al. (4) before AV fistula opening in four patients and peritoneal dialysis in two patients. Twelve of our cases were still continuing hemodialysis through their patent transhepatic catheters. Eighteen patients died of reasons unrelated to catheters while their catheters were functional. Two cases were transitioned to AV fistula and three to renal transplantation. Half of the catheters were functional on day 136 when cumulative patency was taken into consideration. We conclude that the transhepatic route can be used in long term because long-term patency is satisfactory, the complication rates are relatively low, and life expectancy of patients in this group is short.

The main limitation of our study was lack of standardization in catheter selection, procedure, technique, and catheter location, since these procedures were not performed by a standard interventional radiology team. One-to-one comparison with an alternative method was not possible because of the retrospective nature of the study. Despite these limitations, to the best of our knowledge, our study includes the largest series in the literature, but long-term follow-up of cases could be scrutinized. We think that this study makes a significant contribution to the limited literature on transhepatic catheterization.

In conclusion, transhepatic venous catheterization is a safe and functional alternative route in chronic hemodialysis in patients without an accessible central venous route. The procedure can be performed with a high technical success and low complication rate by using imaging guidance. It can be used transiently in patients in whom AV fistula-graft or transplantation is planned, and for long term in patients with low life expectancy and low probability to switch to permanent treatment.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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