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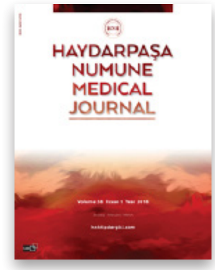

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ORIGINAL ARTICLE

Supraclavicular Brachiocephalic Vein Access for Tunneled Dialysis Catheter Placement in Patients with Bilateral Internal Jugular Vein Thrombosis

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Abstract

Introduction: To evaluate the safety, effectiveness, and outcomes of tunneled dialysis catheters (TDC) placed through supraclavicular brachiocephalic vein (BCV) access in patients with bilateral internal jugular vein (IJV) thrombosis.

Methods: Between January 2017 and October 2020, TDCs were placed through supraclavicular BCV access in 46 patients with bilateral IJV thrombosis. Patient demographics, number of attempts, technical and clinical success rates, complications, and patency rates were noted.

Results: 21 (45.7%) patients were male. The mean age was 65.9 years (range 20–89). All catheters were placed at the first attempt. The right BCV was accessed in 16 (34%) patients. The technical and clinical success rate was 100%. No major complication was encountered. The mean follow-up period was 573.5 (range 50–1698) days. 44/46 (95.7%) of the catheters were functional at 30 days. The infection rate was 2.7/1000 catheter days. 38 catheter exchanges (mean: 1.9, range: 1–6) were required in 20 patients. The primary and secondary patency rates were 77.8% and 95.2% at 6 months, 77.8% and 95.2% at 12 months, and 74.8% and 84.8% at 24 months, respectively.

Discussion and Conclusion: TDC placement through supraclavicular BCV access is a viable option in patients with bilateral IJV thrombosis. High success rates and low complication rates with acceptable outcomes make this route an attractive alternative before proceeding to more complex access routes.

Keywords: Bilateral internal jugular vein thrombosis; brachiocephalic vein; hemodialysis; tunneled dialysis catheter.

Attaining permanent vascular access is crucial in hemodialysis patients. If it is consistent with patients' life-PLAN, the 2019 Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines recommend arteriovenous fistula (AVF) creation as the first choice of vascular access due to its superior outcomes and low complication rates[1].

Though tunneled dialysis catheters (TDCs) are associated with higher complication rates with shorter patency rates, their use in renal replacement therapy has gained enormous importance[2]. TDC use is inevitable when AVF or arteriovenous graft (AVG) creation is not possible or non-functional AVF/AVG is encountered[3]. The right internal jugular vein (IJV) is the recommended access route for TDC placement due to its straight course and superior outcomes[1]. However, there is still no consensus on the most convenient access site when the right IJV is occluded. Both subclavian veins and left IJV is widely used, but studies are reporting a high incidence of either venous stenosis-occlusion and higher complication rates[4,5]. The brachiocephalic vein (BCV) was reported useful in the placement of central venous catheters in the pediatric patient group and even in intensive care unit patients at high risk[6,7]. However, there are limited data on the use of the BCV as the access site in the placement of TDC[8-12].

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The purpose of this retrospective study was to investigate the effectiveness, safety, and outcomes of BCV use as the vascular access site in patients with bilateral IJV thrombosis.

Materials and Methods

Patient Group

The study was designed as a retrospective file review and approved by the institutional review board. Between January 2017 and October 2020, patients who underwent TDC placement were retrospectively reviewed.

Inclusion criteria were: (i) occluded IJVs on both sides; (ii) patent central veins; (iii) Ineligible to create new permanent hemodialysis access. Exclusion criteria were: (i) occluded central veins; (ii) inability to visualize the BCV under ultrasound; (iii) severe allergy to contrast media.

Each patient signed informed consent before the endovascular treatment. Patient demographics, technical and clinical success rates, number of attempts, complications, and patency rates were noted.

Endovascular Technique

All the interventions were performed as an outpatient procedure. Both BCVs were evaluated with color Doppler ultrasound while the patient was lying supine and their neck was hyperextended and rotated on the opposite side. Patency of the IJV, the external jugular vein (EJV), and the femoral veins were assessed under ultrasound guidance with 9–12 Mhz linear-array probe (Logic E10; GE Healthcare, Buc, France). In case of occlusion of the bilateral IJVs, BCVs were evaluated next. US probe was placed above the clavicle and angled caudally to lineate the IJV-SCV junction and the BCV. Right BCV was the first choice access site. In case of access site infection or inability to visualize the right BCV, the left BCV was considered as the next access site. The access side was prepped with chlorohexidine scrub from the chest wall to the base of the ear and sterilely draped. After the administration of local anesthetics, access into the BCV was attained with the micropuncture access set (Mini Access Kits, Merit MAK™, Merit Medical South Jordan, Utah, USA). BCV was punctured with a 21G needle by the in-plane approach, and a 4F introducer sheath was placed over 0.018'' guidewire. The diagnostic angiogram was obtained to confirm the central venous patency. 0.035'' Stiff guidewire (Radiofocus®, Terumo Medical Corporation, Tokyo, Japan) was advanced in the distal inferior vena cava under fluoroscopy guidance. After subcutaneous tunnel creation, TDC (Palindrome Symmetrical Tip Dialysis Catheter; Medtronic Inc., Minneapolis, Minn) was placed over the wire at the atriocaval junction. A cuff-to-tip catheter length of 19 cm was used for the right BCV access, while a distance of 23 cm was used for the left BCV. Catheter functionality was checked, and catheter lumen was flushed with unfractionated heparin/saline solution (1000 units/mL). The procedure was terminated after homeostasis achievement. Routine antibiotic prophylaxis was not administered (Fig. 1).

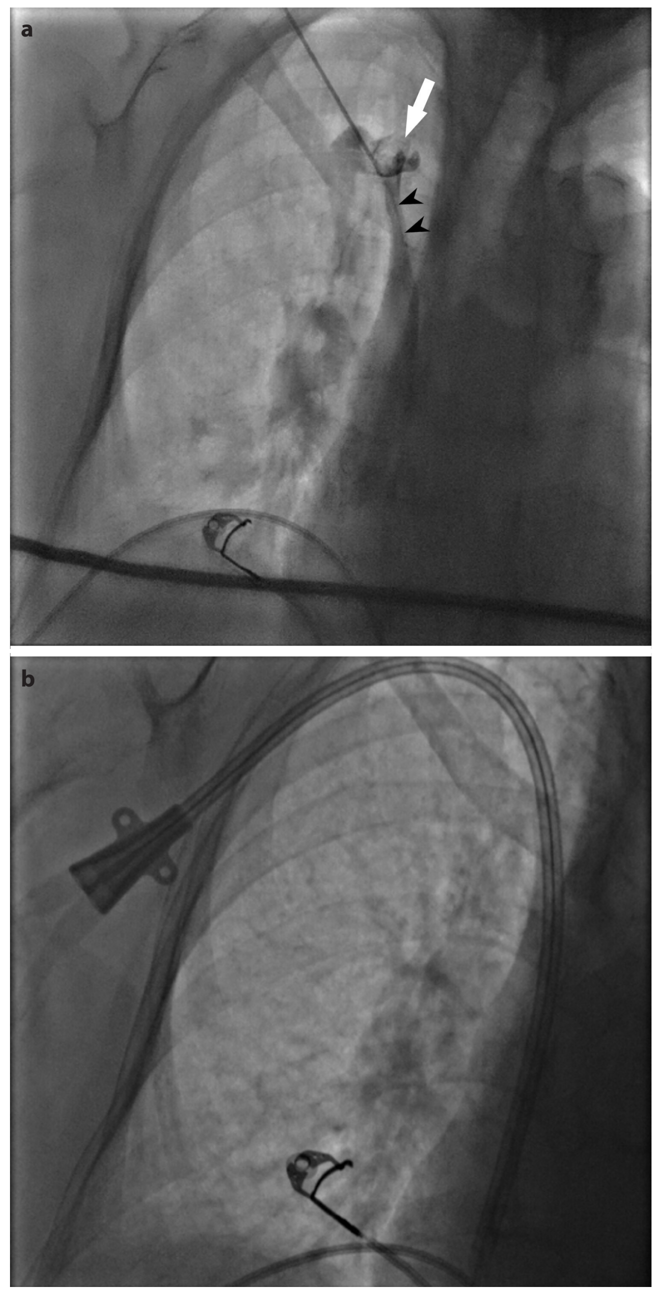

Figure 1. A 48-year-old woman presented with thrombosed left brachiocephalic fistula. **(a)** BCV puncture and contrast media injection reveals a thrombosed right internal jugular vein (arrow) and narrow but patent brachiocephalic vein (arrowheads). **(b)** 19 cm tunneled dialysis catheter was placed at the atriocaval junction.

If catheter dysfunction develops during follow-up declotting procedure is performed first. 1 mg tissue plasminogen activator was instilled in each port and locked for 60 min. When thrombolysis failed, catheter exchange was utilized over the guidewire. In case of fibrin sheath presence, disruption was performed with 8-10mm balloon catheters (Sterling and/or Mustang, Boston Scientific, Marlborough, MA, USA).

Definitions and Outcomes

The primary outcomes of this study were technical success, clinical success, primary and secondary patency rates, and catheter-related bloodstream infection rates. The number of attempts was defined as the number of skin punctures. Technical success was defined as successful puncture of the BCV and TDC placement. Clinical success was defined as at least one successful hemodialysis session with a flow rate >300 mL/min after the procedure. Primary patency was defined as the interval between the intervention and catheter malfunction. Secondary patency is defined as the interval between catheter placement and access abandonment due to catheter malfunction, infection, change in dialysis modality or transplantation.

Catheter dysfunction was defined as Qb<300 mL/min with an arterial pre-pump pressure <–250 mmHg. Exit site infection was defined as hyperemia, tenderness, and induration within 2 cm from the catheter exit site. Tunnel infection was defined as hyperemia, induration, and tenderness, including the whole subcutaneous tunnel tract. Catheter-related blood-stream infection was defined as (i) the presence of clinical signs of infection; (ii) isolation of the same organism from a peripheral source and catheter segment[1].

Complications are classified according to descriptions of the Society of Interventional Radiology Clinical Practice Guidelines[13]. Early complications included arterial puncture, hematoma, air embolism, and pneumothorax. Catheter dysfunction (<300 mL/min), malposition, and infection were considered late complications.

Follow-up

The surveillance program was scheduled for the 1st week, 1, 3, 6, 12 months and annually thereafter. Cumulative patency rate data were obtained from visit records or telephone contacts. Patients were followed till catheter abandonment, death, or study endpoint.

Statistical Analysis

Continuous variables were presented as mean and range. Categorical variables were expressed as numbers and percentages. The Chi-square test was used to compare categorical variables. The Mann–Whitney U test was used to compare the infection rates, and the etiology of the catheter exchanges (thrombosis, fibrin sheath formation, and infection) between TDC insertion sites. Primary and secondary patency rates were evaluated with Kaplan-Meier analysis. All analyses were performed using IBM SPSS version 23 software (SPSS Statistics v23, IBM Corporation, Somers, New York). $p \leq 0.05$ was considered statistically significant.

Results

Forty-six patients were enrolled in the study. Both right and left BCV could not be visualized in two patients due to thick and short necks and were excluded from the study. 21 (45.7%) patients were male. The mean age was 65.9 years (range 20–89). 26 (56.5%) of the patients were diabetic and 23 (50.0%) of the patients had a history of coronary artery disease. Patient demographics are presented in Table 1.

All catheterizations were performed at the first attempt. Right BCV was accessed in 16 (34%) patients. Left BCV was accessed in 30 patients due to access site infection in four (8.7%) and BCV stenosis/occlusion in 26 (56.5%), respectively.

Major complications were not encountered in any of the patients. Persistent hemorrhage through a subcutaneous tunnel occurred in one patient and was treated with prolonged manual compression. No signs of unintentional arterial puncture, air embolism, or pneumothorax were observed.

The mean follow-up period was 573.5 (range 50-1698) catheter days. 44/46 (95.7%) of the catheters were functional at 30 days. A total of 38 catheter exchanges (mean:1.9,

Table 1. Patient demographics

	Number or mean	% or range
Age	68.1	55–84
Sex		
Male	21	45.7
Female	25	54.3
Comorbitities		
Diabetes mellitus	26	56.5
Cardiovascular event	23	50.0
Hypertension	17	37.0
Hyperlipidemia	8	17.4
Smoking history	21	45.7

range 1–6) were required in 20 patients. The mean duration between initial catheter placement and first exchange was 7.9 (range 0.2–22) months. More than one exchange was performed in 9 patients. The underlying etiology of catheter exchange was catheter dysfunction due to thrombosis and fibrin sheath formation in 15 (36.5%) and 19 (50%) of the cases, respectively.

The infection rate was 2.7/1000 catheter days. There were nine episodes of exit-site infection in 8 patients and were treated with 5% povidone-iodine solution and systemic antibiotics. None of the patients experienced tunnel infection. While catheters were removed and exchanged due to refractory infection in 4 (10.5%) patients. Although all these patients had positive blood cultures, catheter tip cultures were sterile in two patients. Procedural details and outcomes are presented in Table 2.

The primary and secondary patency rates were 77.8% and 95.2 at 6 months, 77.8% 95.2% at and12 months, and 74.8% and 84.8% at 24 months, respectively (Fig. 2). 11 (23.9%) of the patients died during follow-up. Four were due to myocardial infarction. The underlying cause was unknown in remaining. Catheters were removed after renal transplantation and AVF creation in two and four patients, respectively, though they were still functional.

Table 2. Procedural details and outcomes

	Number or mean	% or range
Insertion site		
Right	16	34.8
Left	30	65.2
Complications		
Major	0	0
Minor	1	2.1
Technical success	46	100
Clinical success	46	100
Patency at 30 days	44	95.7
Catheter exchanges		
1	11	23.9
2	5	10.9
3	2	4.3
4	0	0
5	1	2.2
6	1	2.2
Etiology of exchange		
Thrombosis	15	39.5
Fibrin sheath	19	50.0
Infection	4	10.5

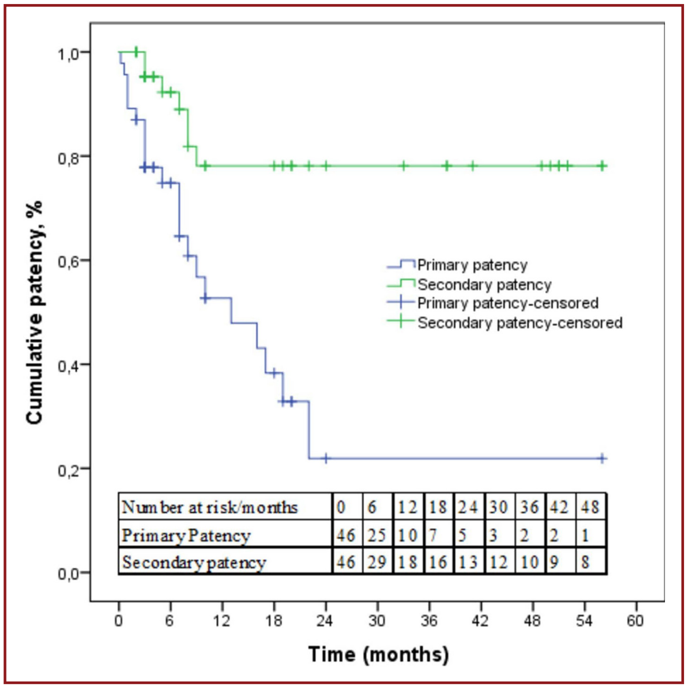

Figure 2. Kaplan–Meier curves demonstrating primary and secondary patency rates.

Discussion

Our study demonstrated that TDC placement through supraclavicular BCV approach is a safe procedure with low complication rates. A high technical success rate was achieved. Comparable outcomes with traditional IJV and SCV routes were observed, which make this route a viable option in patients with bilateral IJV occlusion before proceeding to more complex access sites such as translumbal and transhepatic routes.

Fistula First Breakthrough Initiative has significantly increased the use of AVF in the incident and prevalent hemodialysis patients[14]. However, TDCs are still widely used for either initiation of hemodialysis, a bridge to AVF creation, fistula maturation, or renal transplantation. A considerable amount of patients require TDC as the only vascular access due to exhausted access sites or limited life expectancy[1]. Although TDC gives the opportunity of rapid and painless hemodialysis, they are associated with high morbidity and mortality compared with AVF[15].

A step-by-step approach is mandated in the selection of the vein for vascular access in hemodialysis patients, cause as the duration of hemodialysis increases, the number of options depletes. KDOQI guidelines recommend the right IJV as the first choice of access route for either central venous catheter or TDC placement[1,6]. However, less desirable routes are used when the right IJV thrombosis is encountered. In our institution, right IJV, left IJV, right femoral vein, and left femoral vein were the preferred vascular access order at the time of study beginning. Subclavian vein access is associated with a high risk of central venous stenosis and is spared in case of any chance of future AVF/AVG creation[16-18]. Translumbar and transhepatic routes are considered as least desired routes due to technical challenges and inferior results[19]. In daily practice, a vascular access questionnaire is applied to each patient to measure patient satisfaction, outcomes, and expectation of vascular access. Our results showed that upper extremity TDCs tend to have fewer infection complication rates than femoral TDCs. Moreover, patients emphasize that the use of upper extremity TDCs is more comfortable than femoral TDCs. In light of these results, our interventional radiology department decided to use upper extremity veins more aggressively. Although there is limited data in the literature, the BCV was utilized as the next access route before proceeding to a femoral vein access in case of bilateral IJV thrombosis.

The BCV approach was considered the "an overlooked approach" or "the forgotten central line" due to its early result of a high pneumothorax rate[20,21]. As the use of ultrasound increased in daily practice, lower catheter-related complication rates were reported in the BCV approach compared to the conventional IJV and SCV approach in central venous catheter placement[6]. Furthermore, BCV is the largest vein that is accessible for US-guided cannulation, with a reduced operating time and fewer cannulation attempts, also allowing the introduction of larger catheters compared with IVJ and SCV[7,22].

Left BCV has more potential of complication rate than left BCV due to its deeper location, its relation with the thoracic duct, and incidence of variation. Furthermore, a higher risk of thrombosis was attributed to its tortuous course compared to right BCV[23]. However, left BCV was accessed in the majority of the cases in our group and none of the patients suffered from the above-mentioned potential complications.

There are limited data on the use of BCV in vascular access for hemodialysis patients[8-12]. Falk et al.[8] reported a series of 44 procedures in 33 patients. They achieved a success rate of 100% with a complication rate of 2.5%. All patients underwent at least one successful hemodialysis session. Restrepo Valencia et al.[9] inserted four catheters (one temporary catheter and three TDCs) in three patients without any complications. They emphasized that all three catheters worked properly at eight months follow-up. Gouda et al.[12] reported a study of alternative approaches in patients with bilateral IJV thrombosis. 134 TDCs were implemented in 134. External iliac vein (43.28%), external jugular vein (14.93%), low jugular/BCV (14.16%), and IJV collaterals (7.46%) were the most frequent approaches. They emphasized that BCV and IJV collaterals had better patency at 400 days and the BCV approach was the sole patent access site at 800 days.

One major limitation of the supraclavicular BCV use is the technical difficulties in patients with a short and thick neck and the presence of obesity. In these patients, visualization of the BCV may be challenging, and multiple attempts might be required that might increase the risk of unintentional arterial puncture or pneumothorax. In our group, BCV could not be visualized due to the short and thick neck in two obese patients. The patency of the BCV was confirmed with venography. Femoral veins were utilized in these patients.

There are reports investigating the use of the right EJV as vascular access in hemodialysis patients[24-27]. Wang et al.[24] reported that the use of external jugular veins resulted in higher primary patency rates compared to left IJV in patients with occluded right IJV. Forauer et al.[27] reported a series of ten TDC placements in eight patients with a technical success of 100% without any major complication. However, this route has its own limitations. EJV is a small caliber vein and might have a tortuous course. TDCs have a size of 15-French which requires at least 5 mm vein diameter to accommodate. Also, advancing TDCs through tortuous vessels is another laborious task. Due to the mentioned reasons, EJV was not considered an option in our series.

Femoral venous access is utilized when IJV is not eligible. However, there are controversial results regarding patency and infectious outcomes of femoral vein access compared to conventional IJV access[28-32]. One and 6 months patency is reported in a wide range between 44%–70% and 14%–61%, respectively. Femoral vein catheterization was the next step in our series when BCV is occluded or could not be visualized in high body mass index patients though catheter colonization risk is higher in this patient group[31,32].

Translumbar inferior vena cava TDC placement is proposed as a salvage route but is associated with poor outcomes with relatively low patency rates. The requirement of multiple catheter exchanges is another issue during follow-up[19,33].

Transhepatic TDC placement is also proposed in exhausted vascular access options[34,35]. Respiratory movements may cause catheter migration, kinking, which requires frequent catheter changes to attain long-term hemodialysis[34]. Furthermore, hepatic hemorrhage is also a potential life-threatening complication[35].

No major complication was encountered in our series. A mild hematoma at the subcutaneous tunnel occurred in one patient. Thirty-four catheter exchanges due to malfunction were performed in 16 patients. Fibrin sheath was the cause in 19 cases and was treated with balloon maceration. Thrombosis was the cause in 15 patients and was treated with either tPA administration and longer TDC placement. The catheter malfunction rate is similar to previous reports[12,36,37].

The infection rate was 2.7/1000 catheter days in our study and catheter exchange was required in 4 cases due to persisting infection, which was comparable to previous reports and K-DOQI guidelines[1,38,39]. Prophylactic antibiotics were not administrated routinely, which would decrease the rate of infection rates[40]. There was no statistically significant difference in the infection rates between TDC insertion sites. Early catheter infection was not encountered in the current study.

Our study has inherent important limitations. The study is a single-center experience with a limited number of patients. The lack of randomization and retrospective design has the risk of confounding bias. Direct comparison with other conventional insertion sites was not available. Long-term results are needed.

Conclusion

The supraclavicular BCV approach for TDC placement is an effective, safe access route in patients with bilateral IJV thrombosis. Low complication rates with acceptable patency rates make this option a viable conduit before femoral, translomber, or transhepatic routes. Controlled randomized trials comparing different access routes are warranted.

Ethics Committee Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Our study was approved by the Institutional Review Board (IRB) of Okan University Hospital.

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