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Original Article

# Central Transposition of the Cephalic Vein in Patients with Brachiocephalic Arteriovenous Fistula and Cephalic Arch Stenosis

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**Purpose:** Our study aims to evaluate to evaluate clinical outcomes after cephalic vein transposition (CVT) to the axilla in patients with brachiocephalic arteriovenous fistula (BC-AVF) and cephalic arch stenosis (CAS).

**Materials and Methods:** Hospital records of 13 patients (median age, 61 years; males, 54%) who received CVT to the proximal basilic/axillary vein due to either dysfunction (n=2) or thrombosis (n=11) between January 2010 and February 2014 were retrospectively reviewed.

**Results:** Operation was performed under local anesthesia in all cases. There was no technical failure. Concomitant inflow procedure (banding or aneurysmorrhaphy) was performed in 5 patients (38%). During follow-up (1 to 50 months, median 17 months), 3 patients died with functioning AVF and one was successfully transplanted. Two patients suffered from recurrent symptomatic stenosis of AVF and received percutaneous balloon angioplasty. Another 2 patients experienced AVF occlusion treated with interposition graft and manual fragmentation. Overall primary, assisted primary, and secondary patency rates were 77.5%, 92.3%, and 100% at 6 months and 66.1%, 92.3%, and 100% at 1 year, respectively.

**Conclusion:** Although most patients presented with BC-AVF occlusion, technical success and access patency rates after CVT were favorable compared with historical data for interventional treatment. CVT should be considered as an appropriate option in selected patients with CAS.

**Key Words:** Cephalic, Stenosis, Renal dialysis, Arteriovenous fistula, Transposition

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## INTRODUCTION

Brachiocephalic arteriovenous fistula (BC-AVF) is one of the most commonly used and preferred permanent hemodialysis access options according to the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines [1]. However, these fistulas are frequently complicated by cephalic arch stenosis (CAS), with reported prevalence of 19%-77% among patients with dysfunctional BC-AVF [2,3]. The clinical consequences of CAS are diverse and of significant clinical importance, and include low access flow, high recirculation rate, difficulty in hemostasis, bleeding, aneurysm formation, thrombosis, and eventual fistula loss.

In patients with CAS and BC-AVF, various approaches including endovascular and surgical interventions have been employed to manage cephalic arch lesions [4]. While endovascular interventions are most frequently used, their success is often limited and repeated interventions are

usually required [5-7]. In addition, endovascular treatment of CAS complicated by thrombosis is a difficult and time-consuming procedure due to the associated high burden of thrombus in the aneurysmal dilation of the BC-AVF. These shortcomings lead to technical failure and eventual abandonment of the fistula [8].

The aim of the current study was to report the outcomes of surgical intervention cephalic vein transposition (CVT) to the axilla for managing CAS.

## MATERIALS AND METHODS

### 1) Design and patients

Between January 2010 and February 2014, 399 consecutive patients underwent revision procedures for permanent vascular access dysfunction (239 for native arteriovenous fistulas; 160 for prosthetic arteriovenous fistulas) at Kyungpook National University Hospital, Daegu, Korea. Of these, 69 patients presented with dysfunction of native BC-AVF and received various revision procedures. The types of dysfunction were steal syndrome in 2 patients, hyperfunctioning fistula in 5, stenosis in 37, and occlusion in 25. The main revision procedures were as follows: percutaneous transluminal angioplasty (PTA) in 31 patients (including 4 PTA for CAS), interposition graft in 14, CVT with or without thrombectomy in 13, banding procedure in 5, simple thrombectomy in 4, distal revascularization with interval ligation in 1, and revision using distal inflow in 1. Thirteen patients who received CVT for CAS with BC-AVF (2 patients with AVF dysfunction due to CAS, 11 with AVF occlusion associated with CAS)

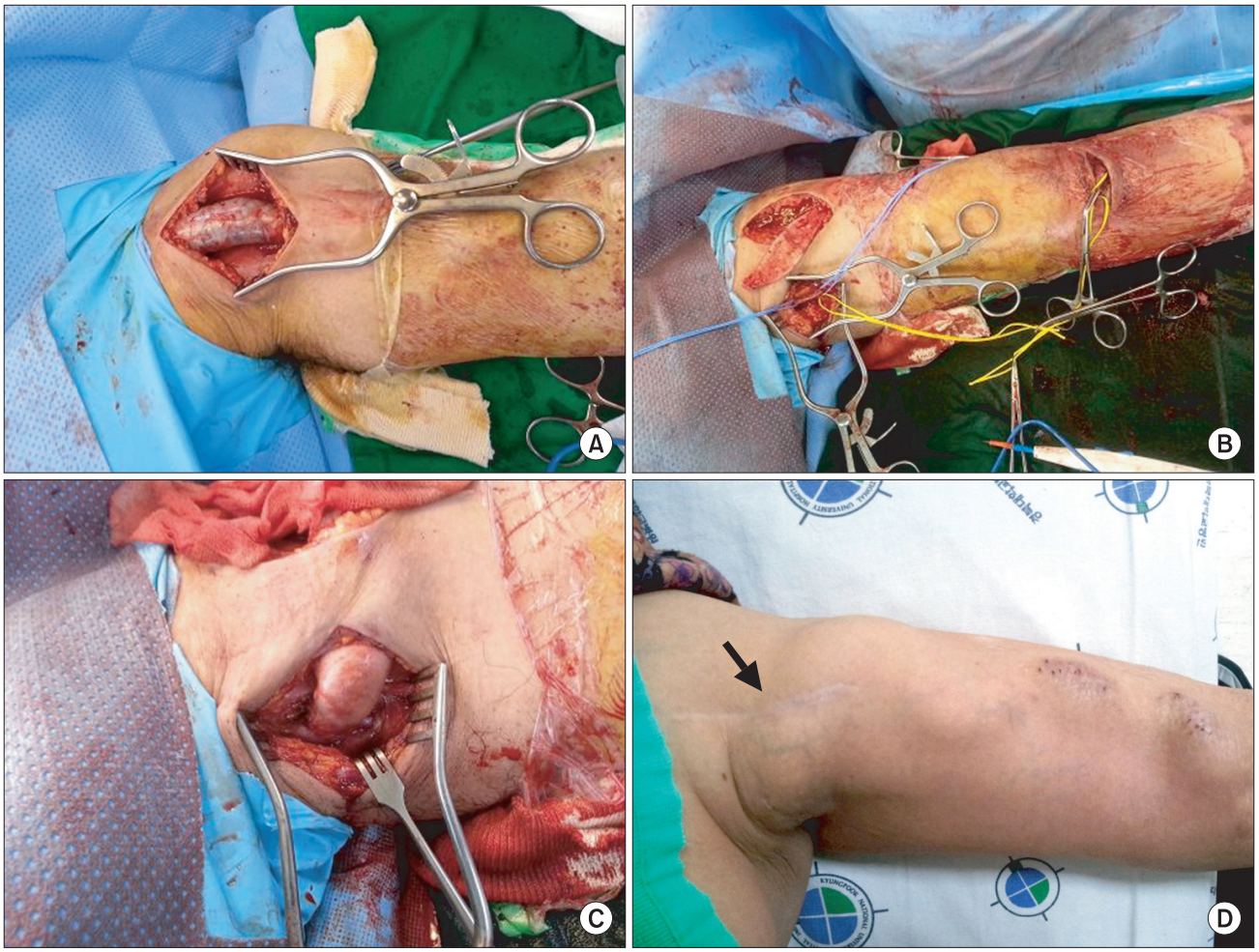



**Fig. 1.** Representative case of cephalic vein transposition for thrombosed brachiocephalic arteriovenous fistula complicated by cephalic arch stenosis. (A) Proximal cephalic vein was mobilized to ensure adequate length for transposition to the axilla. (B) Cephalic vein was transected proximally, and the clots were cleared through the transected end and transverse fistulotomy site distal to the anastomosis with manual milking manipulation. (C) Cephalic vein was anastomosed to the proximal basilic vein in an end-to-side fashion. (D) Well functioning transposed cephalic vein (black arrow) 1 month after surgery.

were included for this study and the result was compared with historical data because the number of PTA for CAS in our series was small (n=4). The diagnosis of CAS was made by duplex ultrasonography (DUS) in all patients. CAS was suspected by physical examination of the AVF such as aneurysmal dilation proximal to the cephalic arch and by history of dialysis function such as prolonged hemostasis and high venous pressure during dialysis. Thereafter, patients had duplex ultrasound examination to evaluate the cephalic arch lesions and adjacent outflow veins prior to surgery. This type of study did not require the approval of the institutional review board and informed consent was obtained from all patients before treatment.

### 2) Surgical procedures

All surgical procedures were performed under local anesthesia with 1% lidocaine. Prophylactic intravenous antibiotic (cephazolin 1 g) was given preoperatively. Most patients presented with thrombotic occlusion of the AVF with CAS. In these patients, the CVT procedure was performed as follows. The proximal cephalic vein was mobilized to ensure adequate length for transposition to the axilla and the hemodialysis cannulation site in the distal cephalic segment was preserved. Another incision was made on the previous anastomosis of the BC-AVF and generally a transverse incision was made on the fistula distal to the anastomosis to facilitate thrombus removal and inflow control. The cephalic vein was transected proximally and the clots were cleared through the transected end and the transverse fistulotomy site with a Fogarty balloon catheter and manual milking manipulation. Another incision was made to expose the proximal basilic/axillary vein after confirmation of thrombus clearance through the flushing of heparinized saline. The transverse fistulotomy site was closed with a 6-0 monofilament suture and the proximal cephalic vein was subcutaneously transposed. The cephalic vein was anastomosed to the basilic/axillary vein in an end-to-side fashion using a 6-0 monofilament suture. For patients without thrombosis, thrombectomy procedures were not necessary. Therefore, inflow control was made at the incision site of the proximal cephalic vein mobilization site and the rest of the CVT was performed as described above (Fig. 1).

In cases where the BC-AVF was considered to be hyperfunctioning due to high flow as judged in the operating room, additional inflow reduction procedures, such as banding or aneurysmorrhaphy at the juxta-anastomotic segment, previously exposed for inflow control and thrombectomy, were performed. Finally, the incisions were closed with sutures after bleeding control.

### 3) Data collection and statistical analysis

This was a retrospective analysis based on a review of patient medical records. If the patients were not able to reach the hospital, details of recurrent events including stenosis and occlusion, revision procedures, and death during follow-up were obtained by telephone contact with the patients or their families. Subsequently, we evaluated the demographics and clinical manifestations of the patients on admission, duration and previous revision procedures of their AVF, as well as their in-hospital and long-term clinical outcomes post-treatment. Outcomes of interest were perioperative complications, patency, revision procedures and death during follow-up.

Primary patency of the transposed cephalic vein was defined as the interval from time of surgery to any intervention designed to maintain the patency of the transposed cephalic vein (including the neo-anastomosis). Assisted primary patency was defined as the interval from time of surgery to access thrombosis/abandonment or time of patency measurement, including endovascular interventions designed to maintain the functionality of a patent access. Secondary patency was defined as the interval from time of surgery to access abandonment, including interventions designed to re-establish the functionality of thrombosed access. Kaplan-Meier survival analysis was performed to estimate the fistula patency and all calculations relied on IBM SPSS Statistics 20.0 (IBM Co., Armonk, NY, USA).

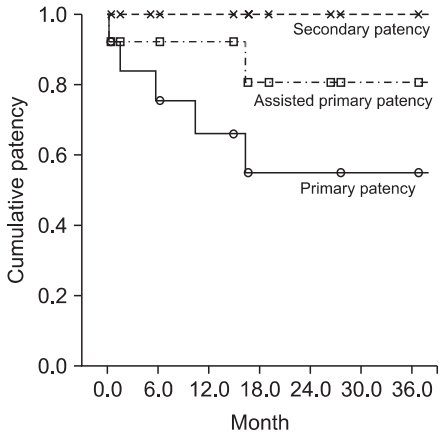
## RESULTS

The demographic and baseline characteristics of the 13 patients are listed in Table 1. The indications for surgical

**Table 1.** Characteristics of patients and fistulas

| Characteristic | Number of patients (n=13) |
|---|---|
| Age (y) | 61 (24-81) |
| Male | 7 (54) |
| Coexisting medical condition | |
| Hypertension | 11 (85) |
| Smoking (current smoker) | 1 (8) |
| Diabetes mellitus | 4 (31) |
| Congestive heart failure | 3 (23) |
| Ischemic heart disease | 4 (31) |
| Fistula age in years | 3.4 (0.4-8.4) |
| Thrombotic occlusion | 11 (85) |
| Prior revision procedures | 4 (31) |

Values are presented as median (range) or number (%).




| No. at risk | | | | | | | |
|---|---|---|---|---|---|---|---|
| Primary patency | 13 | 9 | 7 | 4 | 4 | 3 | 3 |
| Assisted primary patency | 13 | 10 | 9 | 6 | 5 | 3 | 3 |
| Secondary patency | 13 | 10 | 9 | 6 | 5 | 3 | 3 |

**Fig. 2.** Overall primary, assisted primary, and secondary patency rates after cephalic vein transposition.

revision were thrombotic occlusion in 11 patients (85%) and AVF dysfunction with difficulty in hemostasis after removal of dialysis needle in the remaining 2 patients. The mean age of fistula was 4.1±2.8 years (median, 3.4 years) and four previous revision procedures had been performed in 4 patients to maintain functionality. Among the four revision procedures, 2 patients received PTA of the cephalic arch and 2 received banding procedure for their hyperfunctioning fistula.

Concomitant inflow procedures (three banding procedures and two aneurysmorrhaphies of the juxta-anastomotic cephalic vein) were performed in 5 patients (38%). There were no technical failures. In terms of postoperative complications, one patient developed hematoma at the surgical incision site of the proximal cephalic vein dissection that resolved after conservative treatment. No other significant complications were encountered.

The mean follow-up duration was 20.2±15.6 months (median, 16.7 months; range, 1-50 months). During the follow-up period, 3 patients died with functioning AVF and one was successfully transplanted. Two patients suffered from recurrent symptomatic stenosis of the AVF: one patient received PTA of the juxta-anastomic swing segment 5.7 months after CVT and one patient received PTA of the neoanastomosis at the venovenostomy site 10.4 months after CVT. Another 2 patients experienced AVF occlusion during follow-up: one short-segment thrombotic occlusion of the juxta-anastomotic segment developed 5 days after CVT and flow restoration was achieved by manual fragmentation of the thrombosis under the guidance of DUS. One patient demonstrated long segment AVF occlusion due to stenosis of the neoanastomosis 16.3 months after CVT and maintained functionality after thrombectomy with interposition graft. Overall primary, assisted primary, and secondary patency was 77.5%, 92.3%, and 100% at 6 months and 66.1%, 92.3%, and 100% at 1 year, respectively (Fig. 2).

## DISCUSSION

The present case series examined the clinical outcomes of surgical intervention with CVT for the management of symptomatic CAS (either occlusion or dysfunction) in patients with BC-AVF. CVT was effective in salvaging fistulas and a durable option complicated by CAS, although most of our patients presented with BC-AVF occlusion.

The cephalic arch is the perpendicular portion of the cephalic vein in the region of the deltopectoral groove before its junction with the subclavian vein and a sole outflow of BC-AVF. Therefore, development of stenosis in the cephalic arch can be a risk factor for access thrombosis [3]. The reported prevalence of CAS after creation of BC-AVF is approximately 30% and the cephalic arch is the most common site of stenosis after BC-AVF [2]. After creation of a BC-AVF, adaptive dilation of the cephalic arch is a required process to accommodate increased blood flow. However, although not well understood, many patients develop CAS. Several hypotheses have been offered [4]. First, it may be related to the curved and angled course of the cephalic vein in the deltopectoral groove. Therefore, turbulence and shear stress related to this curvature could develop and this environment of low wall shear stress could promote endothelial proliferation, vasoconstriction and platelet aggregation [9,10]. Second, the presence of higher number of valves in this region may be significant. These valves can potentially hypertrophy in the presence of high blood flow and reduce the lumen diameter significantly [11]. Third, the precreation venous diameter may be related to the development of CAS. The diameter of the cephalic arch can vary in size and may impact subsequent failed enlargement. Finally, vascular expansible remodeling in the presence of high flow rates through the fistula may be limited partly due to external compression by the fascia and muscles of this region. Failure of a vessel to dilate in the face of intimal hyperplasia will result in luminal narrowing and obstruction to flow [12,13]. Currently, it is difficult to say whether there is a single mechanism that causes CAS. Perhaps a combination of the aforementioned factors leads to stenosis of the cephalic vein.

There are many options including endovascular PTA

and open surgical revision for venous outflow stenosis. Currently, PTA is considered the first-line therapy in the treatment of venous outflow stenosis [1]. However, studies focusing on the efficacy of PTA for CAS demonstrated less successful results than venous stenosis of other sites [7,14]. Rajan et al. [7] showed that stenosis often requires high inflation pressures (58% of patients required >15 atmospheres). In addition, early restenosis rates are high, leading to a primary patency rate of 42% at 6 months, which is lower than the recommended primary patency rates of the KDOQI guidelines [1]. Also, these stenoses are often complicated by dilation-induced rupture during the procedures [14], which may lead to stent placement or loss of fistula. Because early restenosis after standard PTA is common, other techniques have been used to improve the patency and decrease the necessity of repeated endovascular intervention. However, cutting balloon or bare stent placement failed to improved the primary patency compared with standard PTA in the treatment of CAS [5,6,15]. The reported 1-year primary patency was 38% after cutting balloon angioplasty [5] and 0% after bare stent placement [6]. Recently, covered stents have been used for the treatment of CAS to prevent restenosis and improve patency [6,16]. The early results from these studies are promising with excellent 6-month primary patency (approximately 80% at 6 months). However, the sample sizes were small and a covered stent placed across the cephalic archand advanced into the subclavian vein will jeopardize future use of the basilic and axillary vein for fistula creation if not carefully placed. Therefore, a well-designed large-scale study is necessary to determine the exact efficacy of covered stents.

In our series, 11 patients (85%) were complicated by thrombosis in association with CAS. The restoration of adequate blood flow for dialysis in these patients was more difficult compared to patients without access thrombosis. Thrombotic occlusion of BC-AVF associated with CAS usually presents with aneurysmal dilation of the fistula and leads to large burden of thrombus. Therefore, percutaneous mechanical aspiration or lysis requires significant time for thrombus removal and residual clots in the aneurysmal segment are almost inevitable. Furthermore, balloon angioplasty of the cephalic arch encounters problems like rupture, resistance to dilation, and early recurrence as described above. The reported technical success rates for the failed upper arm fistula has been lower than that of forearm fistula and grafts [17,18]. Despite the large percentage of thrombosed BC-AVF in our series, the technical success rate was 100% and the patency rates were superior to historical results of endovascular treatment [18].

CVT has several drawbacks. First, CVT carries the risk of potential complications due to its invasive nature. Second, CVT may limit other ipsilateral access options, such as a new basilic vein fistula. Third, stenosis at the transposed segment and neo-anastomosis may develop. Actually, 2 patients in our series presented with stenosis of the neo-anastomosis during the follow-up, however these lesions were successfully treated with PTA and interposition graft without abandonment of the fistula. Postoperative complications were unremarkable in our series. Furthermore, assisted primary and secondary patency was excellent after CVT and it eliminated the necessity of temporary catheter for dialysis during follow-up.

A number of limitations to this study should be noted. First, the retrospective design and small sample size relied on previously collected data. This limitation is reflected in the relatively wide 95% confidence intervals. Second, this study may be flawed by selection bias in the study population. This study included patients who received revision procedures due to complications of CAS. Therefore, there is a possibility that the fistula of patients with poor general condition might be abandoned without treatment at presentation. Third, the inflow procedure with banding or aneurysmorrhaphy was decided by the surgeon without objective parameters. Therefore, it was hard to analyze the actual effect of these procedures.

## CONCLUSION

Although most of our patients presented with BC-AVF occlusion complicated by CAS, CVT is effective with respect to higher technical success, and provides excellent assisted primary and secondary patency rates. CVT should be considered as an appropriate option in selected patients with CAS.

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