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Difficult cannulation of hemodialysis arteriovenous fistula – Role of imaging in access management (DICAF STUDY)

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Abstract

Background: Difficulty in cannulation of arteriovenous fistula (AVF) can lead to inadequate dialysis, transient to permanent loss of access and increases dependency on bridging catheters. This study aimed to analyze the causes for difficult fistula cannulation, using various imaging modalities.

Methodology: This was a retrospective single-center observational study conducted between October 2017 and June 2018. Patients whose fistulae were difficult to cannulate were initially evaluated by physical examination followed by doppler ultrasonography or/and fistulogram as necessary. The patients were divided into two groups that is, primary difficult cannulation (within first three months of creation of fistula) or secondary difficult cannulation (after three months).

Results: We encountered difficult cannulation in 43 patients. About 60% were primary difficult cannulations. Most common causes for difficulty in cannulation were cannulation zone (CZ) stenosis (23.3%), immature fistula (20.9%), outflow stenosis (18.6%), inflow stenosis (11.6%), anatomical abnormalities (11.6%), outflow plus CZ stenosis (9.3%) and inflow plus CZ stenosis (4.7%). Among patients with primary difficult cannulation, immature fistula (34.6%) was the most common cause, whereas CZ stenosis (47.1%) was the most common etiology for secondary difficult cannulation. Edema leading to difficult cannulation was found in 12 patients (27.9%), all of which was due to central vein stenosis. Cannulation resulted in hematoma, fistula thrombosis, failure of fistula and pseudoaneurysm in 83.7%, 27.9%, 16.3%, and 2.3% of cases respectively. Bridging temporary dialysis catheter placement was required in 67.4% patients. Ultrasound doppler had lower diagnostic value when compared to fistulogram (71.4% vs 93.9%, $p = 0.014$).

Conclusion: Difficulty in cannulating the arteriovenous fistula is a common problem in hemodialysis patients. We suggest that patients whose fistulae are difficult to cannulate should undergo early radiological evaluation to decrease catheter dependency and access failure.

Keywords

Difficult cannulation, unsuccessful cannulation, arterio-venous fistula, immature fistula, stenosis

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Introduction

The inception of Fistula First Breakthrough Initiative (FFBI) campaign in 2003 has greatly increased the prevalence of AVF use over AV graft (AVG) and central venous catheter worldwide.[1] As an ideal vascular access, AVF should have excellent long-term patency, provide good access blood flow with minimal complications.[2,3] Ease in

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cannulation is the basic requirement for AVFs to minimize complications and ensure its viability.[3–5] Though desirable, this ideal is sometimes difficult to achieve due to various biological and non-biological factors. Cannulation may at times be so difficult as to require multiple attempts and this often leads to iatrogenic complications.[5] While this is usually true with new fistulae, it may be seen with old fistulae also.[6] Deeper fistulae are more difficult to cannulate than superficial ones.[5] Brachiobasilic fistula (BBF) without transposition is more difficult to cannulate than brachiocephalic fistula (BCF) due to proximity of former to brachial artery and anatomical location that is, on medial aspect of arm.[7] It is easier to cannulate autologous AVFs than AVGs. This is may be due to atypical anatomy, deeper location, and poor thrill associated with AVGs.[5] Additionally, underlying anatomical abnormalities within the fistulae can result in difficulty in cannulation of both new and old fistulae. Pre-operative use of vascular mapping like doppler may be unable to prevent this outcome.[8]

Successful AVF cannulation is essential to minimize access related complications and enhance its longevity. Difficult or unsuccessful cannulation may result in poor dialysis blood flow, high venous pressures, inadequate dialysis, poor quality of life, fistula thrombosis, and extra-vascular hematoma.[5] The latter two complications may be a prelude to transient or even permanent loss of access, thus increasing dependency on bridging catheters.[9] Hence, difficulty in cannulation necessitates early evaluation and management. Most studies assume that fistula maturation failure is the cause for difficulty in cannulation[9] and the reasons for difficulty in hemodialysis vascular access cannulation has not been studied adequately. Therefore, in this current study, we aimed to analyze the causes for difficulty in cannulation of arteriovenous fistulae, using various imaging modalities for evaluation. In this study, both mature and immature AVFs were included.

Material and methods

This is a retrospective single-center observational study conducted at a tertiary healthcare teaching hospital in South Asia between October 2017 and June 2018. Patients satisfying criteria of difficult cannulation (defined below) were included. Patients who were unwilling for evaluation or who were lost to follow up or died before completion of their evaluation were excluded from the study. The patients were initially evaluated by physical examination; which was followed by doppler ultrasonography (USG) or/and fistulogram as deemed necessary. Patient related information such as baseline clinical chacteristics, comorbidities, access type, time to first cannulation, and time to difficulty in cannulation, findings of imaging investigation (doppler and fistulogram) and type of intervention done were collected from computerized hospital records.

Definitions used in this study

Difficult Cannulation: All AVFs that had received sufficient time (at least six weeks) for maturation and had one of the following were included.

(1) when AVF cannulation was not attempted due to anticipation of difficulty. This was confirmed by two senior dialysis personnel and one nephrologist.
(2) Failure to cannulate on three or more occasions in four consecutive dialysis sessions, despite being attempted by two different senior dialysis personnel.
(3) Requirement of sonological guidance for cannulation on three or more occasions in four consecutive dialysis sessions.
(4) Cannulations resulting in adverse outcome such as severe pain and/or swelling and/or hematoma and/or aneurysm on three or more occasions in four consecutive dialysis sessions.
(5) Cannulations resulting in partial or complete thrombosis of fistulae, requiring either rest to the fistula for a period of more than two weeks; or requiring urgent interventions like anticoagulation or thrombolysis; or causing permanent AVF failure.
(6) Need to shift either temporarily (more than two weeks) or permanently to alternative treatment modalities or vascular access.

Etiology of difficulty cannulation: This was based on both clinical observation and imaging findings. It was deemed important to consider both as using imaging alone may not be clinically relevant, as some abnormalities are detected incidentally during imaging alone.

Primary or secondary difficult cannulation: We defined primary, as occurring within first 3 months and secondary, after first 3 months of fistula creation.

Abnormal doppler Ultrasound: If the imaging showing evidences of fistula thrombosis, stenosis, aneurysm or hematoma.

Abnormal Fistulogram: Fistulogram was considered abnormal if it showed features of stenosis, occlusion or aneurysm. Stenosis/occlusion could be inflow stenosis (arterial, anastomotic and juxta-anastomotic), cannulation zone (CZ)/ puncture zone (PZ) stenosis or outflow stenosis (cephalic arch (CA), and central vein).[10–13]

Time to first cannulation: Period between AVF creation and initial attempt at AVF cannulation. Time to difficult cannulation: Period between fistula creation to first unsuccessful cannulation.

Statistics

Subjects were divided into two groups that is, primary or secondary difficult cannulation. Normality of the continuous variables were examined using Kolmogorov–Smirnov

test. Data was presented as mean ± standard deviation or median (interquartile range "IQR") or percentage as appropriate. Unpaired Student *t*-test, Mann–Whitney *U*-test, Pearson's Chi-square test and Fisher's exact test were used for comparative analysis between two groups as appropriate. $p < 0.05$ was considered as statistically significant. Statistical package for social sciences, version-25 (SPSS-25, IBM Chicago, USA) was used for statistical analyses. This study was approved by the Institutional Review Board (IRB), Christian Medical College, Vellore (IRB No. 11458). Waiver of consent was permitted by the ethics committee as the data was de-identified and collected retrospectively from hospital electronic medical records.

Results

Baseline characteristics

During the study period, as per our criteria, we faced difficulty in cannulating 57 fistulae (Table 1). Patients who were unwilling for evaluation ($n = 9$) or were lost to follow up ($n = 4$) or who died before complete evaluation ($n = 1$) were excluded from the study. The remaining 43 patients underwent evaluation as per protocol to elucidate the underlying etiology. Of the 43 patients, 26 (60.5%) were primary and 17 (39.5%) were secondary difficult cannulations. Majority of fistulae were created on the left side (88.4%) with ultrasound doppler being the most commonly used (55.8%) pre-operative mapping modality. Two-third of the patients with secondary difficult cannulation did not undergo any pre-operative radiological mapping. Majority of patients (67.4%) had jugular catheter insertion on opposite side of AVF prior to creation of fistula. However, one third of the patients with primary difficult cannulation had jugular catheter insertion on both sides. Median time to difficult cannulation was 3 (1.3–10) months. The median time to first cannulation was longer in the primary group [2 month (1.0–3.0) vs 1 month (1.0–1.5), $p = 0.018$]. Cannulation was not attempted in eight fistulae as they had failed to mature.

Etiology of difficult cannulation

Over all, the etiologies of difficult cannulation were CZ stenosis (23.3%), immature fistula (20.9%), outflow stenosis (18.6%), inflow stenosis (11.6%), anatomical abnormalities (11.6%), outflow plus CZ stenosis (9.3%) and inflow plus CZ stenosis (4.7%) (Table 2). In patients with primary difficult cannulation, immature fistula (34.6%) was the most common cause followed by outflow stenosis (26.9%), anatomical cause (19.2%), inflow stenosis (7.7%), CZ stenosis (7.7%) and outflow plus CZ stenosis (3.8%). The etiology of immature fistula included presence of an accessory vein ($n = 6$), thin feeding artery ($n = 1$), double outflow tract ($n = 1$) and dilated cardiomyopathy (DCMP) with low blood pressure ($n = 1$). Of the nine AV fistulae which failed to mature, five, three, and one were radiocephalic fistulae (RCF), brachiocephalic fistulae (BCF) and median cubital vein (MCV) fistula respectively. In three cases, cardiac dysfunction contributed to poor maturation either directly ($n = 1$, due to low blood pressure) or indirectly (accessory vein = 1 and thin feeding artery = 1). Anatomical causes included BBF without transposition ($n = 3$), BCF with depth of cephalic vein more than 13 mm ($n = 1$) and brachioaxillary graft ($n = 1$). Similarly, among patients with difficult secondary cannulations, the most common cause was CZ stenosis (47.1%), followed by inflow stenosis (17.6%), outflow plus CZ stenosis (17.6%), inflow plus CZ stenosis (11.8%), and outflow stenosis (5.9%). Edema leading to difficult cannulation was found in 12 patients (27.9%, Primary = 08, secondary = 04). All these patients with limb edema had central vein stenosis. Four patients with limb edema had both central vein and CZ stenosis.

Findings on imaging tests

Diagnostic doppler ultrasound, fistulogram or both were done to evaluate etiology of difficult cannulation in 35 (81.4%), 33 (76.7%), and 22 (51.2%) patients, respectively (Table 2). Arterial, juxta-anastomotic, cannulation zone, cephalic arch (CA) and central stenosis were noted in 1 (2.3%), 7 (16.3%), 16 (37.2%), 7 (16.3%), and 12 (27.9%) instances, respectively (Figure 1). Multifocal stenosis was noted in 13 (30.2%) patients. Double outflow tract and accessory vein were found in four (9.3%) and six (14%) patients respectively. Ultrasound doppler had lower diagnostic value when compared to fistulogram (71.4% vs 93.9%, $p = 0.014$). Clinical examination could predict underlying pathology in 74.4% of cases, more accurately in primary difficult. 7/13 (53.8%) cases of multifocal stenosis, 3/10 (30%) cases of CZ stenosis and 1/4 (20%) cases of anatomical abnormalities could not be diagnosed clinically.

Complications of difficult cannulation and treatment

Difficult cannulations led to following complications-hematoma formation in 36 patients (83.7%), fistula thrombosis in 12 patients (27.9%), fistula failure in 7 (16.3%) and pseudoaneurysm formation in one patient (2.3%) (Table 3). Over two-third of these patients shifted to bridging dialysis catheter and one patient opted for peritoneal dialysis. Two patients (4.7%) underwent renal transplantation from this cohort. Site of AVF cannulation was changed in 10 patients (23.3%). Five patients (11.6%) required ultrasound guided cannulation. Accessory branch ligation was done in four patients (15.4%), fistuloplasty in

Table 1. Baseline clinical characteristics.

Parameter (*n*)	Total Cohort (*N* = 43)	Primary difficult cannulation (*N*1 = 26)	Secondary difficult cannulation (*N*2 = 17)	*p* Value
Age (years, mean ± SD)	50.7 ± 12.0	50.6 ± 12.9	51 ± 11.0	0.912
Gender				
Males (*n*/*N*, %)	26/43 (60.5)	18/26 (69.2)	8/17 (47.1)	0.146
BMI (kg/m², median (IQR))	25.8 (22.0–29.5)	25.2 (21.5–29.5)	27 (22.6–30.9)	0.326
Native kidney disease (*n*/*N*, %)				
Diabetic kidney disease	24/43 (55.8)	16/26 (61.5)	8/17 (47.1)	0.682
Hypertensive nephrosclerosis	1/43 (2.3)	0	1/17 (5.9)	
Chronic glomerulonephritis	5/43 (11.6)	3/26 (11.5)	2/17 (11.8)	
Chronic interstitial nephritis	1/43 (2.3)	1/26 (3.8)	0	
ADPKD	2/43 (4.7	1/26 (3.8)	1/17 (5.9)	
Unknown	10/43 (23.3)	5/26 (19.2)	5/17 (29.4)	
Co-morbidities (*n*/*N*, %)				
Diabetes mellitus	25/43 (58)	17/26 (65.4)	8/17 (47.1)	0.234
Hypertension	40/43 (93)	23/26 (88.5)	17/17 (100)	0.266
Coronary artery disease	14/43 (32.6)	6/26 (23.1)	8/17 (47.1)	0.101
DCMP	7/43 (16.3)	5/26 (19.2)	2/17 (11.8)	0.685
CVA	6/43 (14.0)	5/26 (19.2)	1/17 (5.9)	0.376
PVD	2/43 (4.7)	1/26 (3.8)	1/17 (5.9)	0.757
Neuropathy	13/43 (30.2)	10/26 (38.5)	3/17 (17.6)	0.146
Tuberculosis	2/43 (4.7)	1/26 (3.8)	1/17 (5.9)	0.757
Chronic hepatitis B	5/43 (11.6)	3/26 (11.5)	2/17 (11.8)	0.982
Chronic hepatitis C	2/43 (4.7)	1/26 (3.8)	1/17 (5.9)	0.757
Chronic liver disease	3/43 (7)	2/26 (3.8)	1/17 (5.9)	0.820
Jugular insertion (*n*/*N*, %)				
Same side of AVF	4/43 (9.3)	1/26 (3.8)	3/17 (17.6)	0.042
Opposite side of AVF	29/43 (67.4)	16/26 (61.5)	13/17 (76.5)	
Both side	10/43 (23.3)	9/26 (34.6)	1/17 (5.9)	
Type of AVF (*n*/*N*, %)				
Radio-cephalic fistula	12/43 (27.9)	7/26 (26.9)	5/17 (29.4)	0.782
Brachio-cephalic fistula	21/43 (48.8)	13/26 (50)	8/17(47.1)	
Brachio-basilic fistula	6/43 (14)	4/26 (15.4)	2/17 (11.8)	
Median cubital vein fistula	3/43 (7.0)	1/26 (3.8)	2/17 (11.8)	
Graft (Axillary)	1/43 (2.3)	1/26 (3.8)	0	
Side of AVF (*n*/*N*, %)				
Left side	38/43 (88.4)	23/26 (88.5)	15/17 (88.2)	0.982
Right side	5/43 (11.6)	3/26 (11.5)	2/17 (11.8)	
Pre-operative mapping (*n*/*N*, %)				
No mapping	18/43 (41.9)	7/26 (26.9%)	11/17 (64.7)	0.043
Ultrasound doppler	24/43 (55.8)	18/26 (69.1)	6/17 (35.3)	
Doppler + Venogram	1/43 (2.3)	1/26 (3.8)	0	
AVF never cannulated (*n*/*N*, %)	8/43 (18.6)	8/26 (30.8)	–	–
Time to first cannulation (months, median (IQR))	1.5 (1–2)	2 (1–3)	1 (0.5–1.5)	0.018
Time to difficult cannulations (months, median (IQR))	3 (1.3–10)	2 (1–3)	15 (6–29.5)	<0.001

ADPKD, Autosomal polycystic kidney disease; AVF, Arteriovenous fistula; BMI, body mass index; CVA, Cerebrovascular accident; DCMP, Dilated cardiomyopathy; IQR, Inter quartile range; PVD, Peripheral vascular disease; SD, Standard deviation.

11 patients (25.6%), and three patients (7 %) underwent surgical intervention. Cannulations became easy in the post-intervention period in 14/18 (77.8%) patients who underwent interventions. Three patients with left brachiocephalic stenosis had angioplasty failure and one patient with dilated cardiomyopathy with immature fistula due to accessory vein did not improve after accessory vein ligation.

Table 2. Etiology of difficult cannulations and imaging findings.

Parameter (*n*)	Total cohort (*N* = 43)	Primary difficult cannulation (*N*1 = 26)	Secondary difficult cannulation (*N*2 = 17)	*p* Value
Etiology (*n*/*N*, %)				
Anatomical	5/43 (11.6)	5/26 (19.2)	0	0.054
Immature fistula*	9/43 (20.9)	9/26 (34.6)	0	0.006
Inflow stenosis	5/43 (11.6)	2/26 (7.7)	3/17 (17.6)	0.319
CZ stenosis	10/43 (23.3)	2/26 (7.7)	8/17 (47.1)	0.003
Outflow stenosis**	8/43 (18.6)	7/26 (26.9)	1/17 (5.9)	0.083
Inflow + CZ stenosis	2/43 (4.7)	0	2/17 (11.8)	0.073
Outflow** + CZ stenosis	4/43 (9.3)	1/26 (3.8)	3/17 (17.6)	0.128
Diagnostic value (*n*/*N*, %)				
Clinical examination	32/43 (74.4)	24/26 (92.3)	8/17 (47.1)	0.001
Doppler	25/35 (71.4)	12/21 (57.1)	13/14 (92.9)	0.021
Fistulogram	31/33 (93.9)	14/16 (87.5)	17/17 (100)	0.227
Imaging findings*** (not mutually exclusive)				
Normal	6/43 (13.9)	6/26 (23.1)	0	0.066
Arterial stenosis	1/43 (2.3)	1/26 (3.8)	0	0.413
Juxta anastomotic stenosis	7/43 (16.3)	2/26 (7.7)	5/17 (29.4)	0.059
CZ stenosis	16/43 (37.2)	3/26 (11.5)	13/17 (76.5)	<0.001
Cephalic arch stenosis	7/43 (16.3)	4/26 (15.4)	3/17 (17.6)	0.844
Central stenosis	12/43 (27.9)	7/26 (26.9)	5/17 (29.4)	0.859
Multifocal stenosis	13/43 (30.2)	5/26 (19.2)	8/17 (47.1)	0.052
Accessory vein	6/43 (14.0)	6/26 (23.1)	0	0.066
Thin feeding artery	1/43 (2.3)	1/26 (3.8)	0	0.413
Double outflow	4/43 (9.3)	1/26 (3.8)	3/17 (17.6)	0.284
Aneurysm	4/43 (9.3)	1/26 (3.8)	3/17 (17.6)	0.128

CZ: cannulation zone.
*Does not include inflow stenosis. **All cases of outflow stenosis presented with limb edema leading to difficult cannulation. ***Includes both Doppler and Fistulogram Findings.

Discussion

We found difficulty in cannulation of AVF in 43 patients who fulfilled the inclusion and exclusion criteria. About 60% had primary and 40% secondary difficult cannulation. The most common cause of difficult cannulation was CZ stenosis (23.3%) followed by immature fistula (20.9%); outflow stenosis (18.6%); inflow stenosis (11.6%), anatomical (11.6%), outflow plus CZ stenosis (9.3%) and inflow plus CZ stenosis (4.7%). Among patients with primary difficult cannulation, immature fistula (20.9%) was the most common cause, whereas the most common cause of secondary difficult cannulation was CZ stenosis (47.1%).

AVF stenosis can lead to difficulty in cannulation, painful arm edema, prolonged bleeding after removal of fistula needles, inadequate dialysis either due to poor blood flow or recirculation, fistula thrombosis and even loss of fistula.[10,14] Endothelial cell injury is the inciting event, which leads to smooth muscle proliferation and neointimal hyperplasia. Factors that often lead to endothelial injury are shear stress from turbulent blood flow, mechanical trauma from venipuncture and temporary catheter, and angioplasties.[15] In our cohort, stenosis was the most common (67.5%) cause for difficult cannulation.

"Failure to maturation" (FTM) of AVF ranges between 14% and 41% and is an important factor that limits functioning of fistulae among hemodialysis population.[9,16,17] In our study, it was an important cause of difficult cannulation accounting for quarter of cohort. As in previous studies, presence of an accessory vein (54.5%), and inflow stenosis (18.2%) were two important and treatable causes of immature AVF.[11,18–20] The former was due to impaired venodilatation and later related to accelerated venous neointimal hyperplasia.[19,20] Underlying cardiac dysfunction, coronary artery disease and low blood pressure are known risk factors for immature AVF.[21] In our study, we found that cardiac dysfunction was associated with poor maturation of AVF both directly ($n = 1$, due to low blood pressure) and indirectly (accessory vein, $n = 1$, and thin feeding artery, $n = 1$). High incidence of immature fistula due to accessory vein ($n = 6$) and cardiac dysfunction ($n = 3$) suggest that along with mapping of blood vessels, high-risk patients should also undergo cardiac evaluation prior to surgery.[22]

Edema of the fistula limb is a manifestation of venous hypertension. It is an important cause of unsuccessful cannulation and is mostly due to due to central stenosis.[5,22,23]

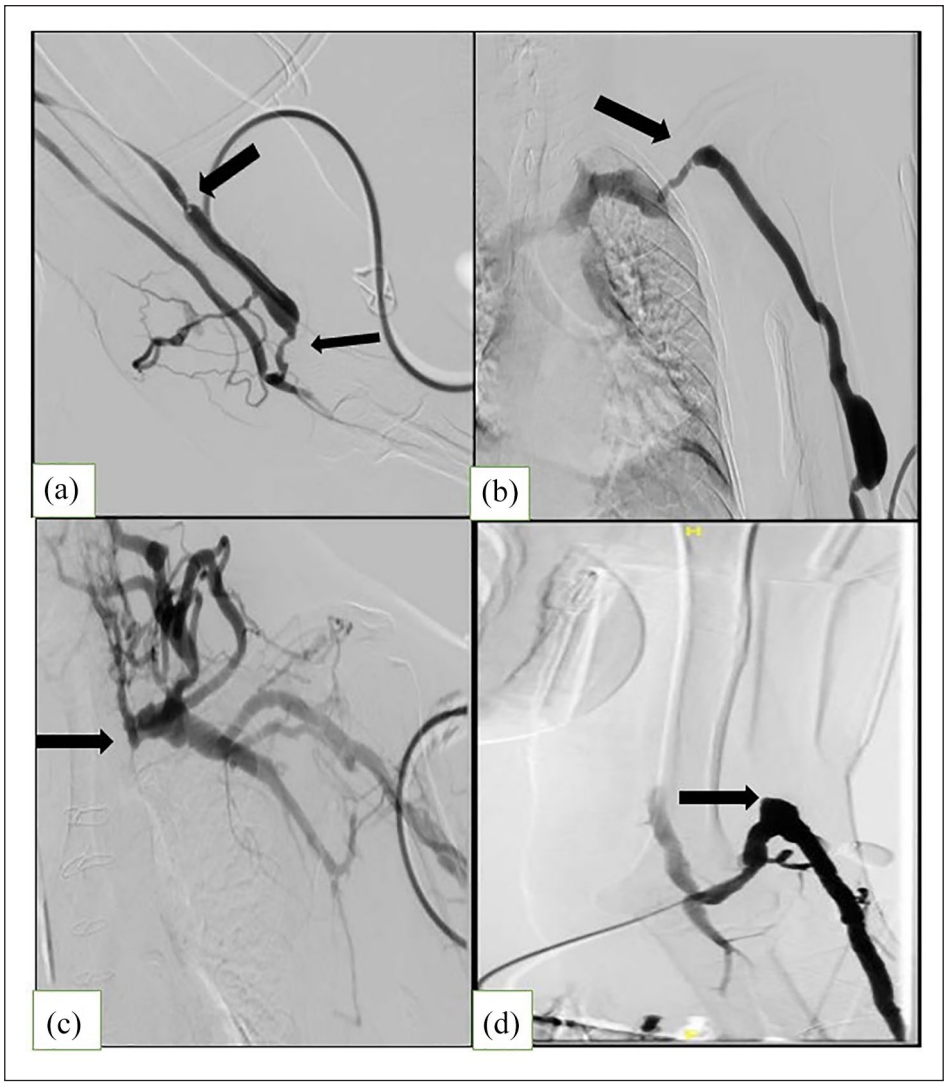

Figure 1. (a) Fistulogram of left brachiocephalic fistula with stenosis at juxta anastomotic site (thin arrow) and cannulation zone (thick arrow), (b) fistulogram of left brachiocephalic fistula with cephalic arch stenosis (Arrow), (c) fistulogram of left brachiocephalic fistula with stenosis of brachiocephalic vein (Arrow), and (d) fistulogram of median cubital vein fistula with complete stenosis of cephalic vein (Arrow).

In our study, limb edema was one of the major causes of difficult cannulation accounting for 27.9% of total cases and 30.8% of primary group. Central stenosis was the sole cause in our cohort. This is likely secondary to prior temporary dialysis catheter placement.[24] This could perhaps have been avoided by pre-operative venogram in patients with history of jugular or subclavian cannulation on the same side as the fistula. Another important cause of difficult cannulation was the anatomical location of fistula, which included BBF without transposition (60%), BCF with depth of cephalic vein more than 13 mm (20%) and brachioaxillary graft (20%). AVF that is located on medial aspect of the arm or with depth more than 6 mm is usually difficult to cannulate. This cannulation difficulty could have been preempted by improved surgical techniques such as transposition or superficialization.[5,25]

Hematoma (83.7%) was most common complication of difficult cannulation, followed by fistula thrombosis (27.9%), failure of fistula (16.3%) and pseudoaneurysm (2.3%), as described in previous studies.[5–7] Difficult cannulation leads to increase dependency on bridging catheter that increases risk of catheter related blood stream infections and mortality.[6,26,27] Though not statistically significant, dependency on bridging catheter was numerically higher in the primary (80.8%) compared to secondary (47.1%) group ($p=0.210$). This may be due to higher prevalence of immature fistula in the primary group (42.3%), which needed longer time for fistula use even after intervention.

Lower diagnostic value of doppler in delineating underlying pathology was observed compared to fistulogram (71.4% vs 93.9%, $p=0.014$) because the former is usually less sensitive for cephalic arch stenosis and central stenosis.

Table 3. Complications and treatment.

Parameter (*n*)	Total cohort (*N* = 43)	Primary difficult cannulation (*N*1 = 26)	Secondary difficult cannulation (*N*2 = 17)	*p* Value
Complications (*n*/*N*, %)				
Pain	16/43 (37.2)	12/26 (46.2)	4/17 (23.5)	0.133
Hematoma	36/43 (83.7)	20/26 (76.9)	16/17 (94.1)	0.215
Edema	14/43 (32.6)	12/26 (46.2)	2/17 (11.8)	0.019
Pseudoaneurysm	1/43 (2.3)	1/26 (3.8)	0	0.413
Fistula thrombosis	12/43 (27.9)	6/26 (23.1)	6/17 (35.3)	0.492
Fistula failure	7/43 (16.3)	5/26 (19.2)	2/17 (11.8)	0.685
Treatment Modality (*n*/*N*, %) (not mutually exclusive)				
Bridging catheter	29/43 (67.4)	21/26 (80.8)	8/17 (47.1)	0.210
USG guided cannulation	5/43 (11.6)	4/26 (15.4)	1/17(5.9)	0.633
Change of cannulation site	10/43 (23.3)	2/26 (7.7)	8/17 (47.1)	0.007
Closure of AVF	3/43 (7)	3/26 (11.5)	0	0.226
New AVF creation	3/43 (7)	3/26 (11.5)	0	0.226
Surgical intervention*	3/43 (7)	2/26 (7.7)	1/17 (5.9)	0.820
Thrombolysis/angioplasty	11/43 (25.6)	5/26 (19.2)	6/17 (35.3)	0.080
Accessory vein ligation	4/43 (15.4)	4/26 (15.4)	0	0.038
Change of RRT modality	3/43 (7)	3/26 (11.5)	0	0.511
Shifted to peritoneal dialysis	1/43 (2.3)	1/26 (3.8)	0	
Underwent renal transplantation	2/43 (4.6)	2/26 (7.7)	0	

AVF: arterio-venous fistula; RRT: renal replacement therapy; USG: ultrasound.
*Accessory vein ligation not included.

Similarly, fistulogram is not useful for difficult cannulation due to anatomical causes. The most common sites of stenosis in our cohort were CZ stenosis (34.9%), swing point stenosis [32.6% (JA stenosis = 16.3% and CA stenosis = 16.3%)] and central stenosis (27.9%) which correlates with earlier findings.[10] JA stenosis and CZ stenosis were significantly higher in the secondary group. The former likely due to shear stress from turbulent blood flow and the later due to mechanical trauma from venipuncture.[15]

Most of the studies till date [9] have accepted that difficult cannulation and immature fistula are synonymous. Our study is the first to address difficult cannulation in matured arteriovenous fistula. This study however is limited by its retrospective nature, short study period and small sample size.

Conclusion

Difficult cannulation of arteriovenous fistula is an underestimated problem and a grey area of nephrology practice. The most common etiologies for this problem are stenosis, immature fistula, limb edema, anatomical abnormalities or a combination of these. We suggest that patients whose fistulae are difficult to cannulate should undergo early evaluation to decrease catheter dependency and access failure. Improved patient selection, pre-operative vascular mapping with doppler and improved surgical technique may decrease incidence of primary difficult cannulation. Patient with history of central vein cannulation should undergo pre-operative venogram to rule out central vein stenosis.

Declaration of conflicting interests

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Ethical Statement

Approval was obtained from the Institutional Review Board (IRB), Christian Medical College, Vellore (IRB No. 11458). Waiver of consent was permitted by the ethics committee as the data was de-identified and collected retrospectively from hospital electronic medical records. This manuscript in part or in full has not been submitted anywhere. All authors mentioned in the manuscript have agreed for authorship, read and approved the manuscript, and given consent for submission and subsequent publication of manuscript.

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