Surgical modalities for salvage of aneurysm of arteriovenous access

Original Article

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ABSTRACT

Background: Aneurysmal dilation of arteriovenous (AV) fistulas is not an uncommon occurrence. True aneurysms and pseudoaneurysms are two types of AV fistula aneurysms.

Aim: The aim of the study was to evaluate the different surgical modalities for the management of AV aneurysmal dilatation as a complication of AV access for dialysis in patients with end-stage renal disease on regular hemodialysis (ESRD) regarding the feasibility, patency, clinical success, access salvage rates, and complications.

Patients and Methods: This study is prospective and was conducted on 18 patients with AV aneurysmal dilatation with ESRD as a complication of AV access for dialysis at Beni-Suef University Hospital, Department of Vascular and General Surgery from December 2020 to May 2022.

Results: The current study showed that the only significant variable that affected the occurrence of complications was the type of operation, as no complications were detected in aneurysmectomy, and end-to-end anastomosis was least detected in aneurysmectomy and graft. There was a significantly higher operative time in patients with general anesthesia than in local and regional. Also, the operative time of patients with regional anesthesia was significantly higher than that with local anesthesia.

Conclusion: The different surgical modalities for the management of AV aneurysmal dilatation as a complication of AV access for dialysis in patients with ESRD can be used safely with good clinical success to salvage VARA (Vascular access Related aneurysm) with minimal complications; the least was detected to be related to aneurysmorrhaphy, followed by aneurysmectomy with an interposition graft. When we confirm central vein stenosis, we advise endovascular treatment for the underlying stenosis. Finally, conservative treatment is preferred for asymptomatic aneurysmal fistulae.

Key Words: Aneurysmal dilation, arteriovenous fistula aneurysm, pseudoaneurysm, VARA.

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INTRODUCTION

Arteriovenous fistulae (AVF) form to facilitate hemodialysis in cases with end-stage renal disease (ESRD). Although AVF is an important treatment for these cases, its induction is not without complications[1].

AVF is the most reliable and long-lasting permanent vascular access method and has been the method of choice in practice (AVF is the safest and most reliable means to introduce hemodialysis into patients over the long term)[2].

Aneurysmal dilatation is a potential complication that may result in rupture and bleeding that is potentially fatal. The incidence rate of aneurysm development is ~5–6%. Repetitive punctures at focused locations may result in aneurysm formation due to wall weakness. Proximal stenosis can occasionally hasten the progression by increasing the pressure within the AVF[3].

Prolonged, untreated aneurysms may give rise to short-term and long-term complications[4]. Short-term complications may manifest as symptoms related to endocarditis, rupture, emboli, local compression, or rupture; long-term complications may include dilatation, venous hypertension, or distal ischemia.

In the event that cutaneous infections, fistulas, or signs of distal vascular failure in the extremity manifest, it is imperative to perform surgery on the aneurysm, as there is a heightened risk of rupture[5].

Stable aneurysms are visible, and simple ultrasound and clinical surveillance may be sufficient after baseline measurements[6].

In cases in which an aneurysm has ruptured or where rupture is imminent, immediate ligation of the aneurysm is necessary. If the site is peri-anastomotic and the artery is involved, reconstruction may be necessary. Although

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there are cases in which the fistula can be salvaged, the primary objective is to prevent and manage life-threatening hemorrhage due to the high flow volumes observed in aneurysmal VA[7].

Surgical or radiological treatment options are available, with the optimum outcome being the maintenance of as much definitive access as possible. Surgical options should be investigated in an effort to salvage the AVF. It might be feasible to perform an end-to-end anastomosis reconstruction of the AVF by excising the aneurysm, mobilizing its extremities, and rejoining it if the aneurysm is small and discrete within a tortuous AVF[8].

This has the benefits of preserving the AVF, eliminating the need for prosthetic material, and potentially enabling the fistula to be utilized for needling in the unaffected segments. Endovascular techniques alone or in combination with surgical intervention have managed AVF aneurysms[9].

The objective of this research was to assess the different surgical modalities for the management of AV aneurysmal dilatation as a complication of AV access for dialysis in cases with ESRD on regular hemodialysis regarding the feasibility, patency, clinical success, access salvage rates, and complications.

PATIENTS AND METHODS:

This was an interventional prospective study conducted on 18 patients with AV aneurysmal dilatation with ESRD as a complication of AV access for dialysis. This study was conducted at Beni-Suef University Hospital, Department of Vascular and General Surgery. The study was conducted from December 2020 to May 2022.

Ethical approval

The cases who participated in the research were fully apprised of the research's protocols and their right to reject participation or resign from the investigation without the obligation to explain. We assured the anonymity of patients and handled any information they disclosed with strict confidentiality. The research ethics committee (REC) of Beni-Suef University will acquire ethical sanction before the study begins.

Inclusion criteria

Cases affected by AVF aneurysmal dilatation and skin erosion overlying, the minimum length of the potential cannulation site, anxiety that hides the AV access, low flow as a result of stenosis associated with aneurysms, and massive diffuse venous dilatation.

Exclusion criteria

Infected AVF and patient refusal of intervention.

Surgical procedures

All surgical processes were conducted under conscious sedation with local anesthesia, regional anesthesia, or general anesthesia. Prophylactic intravenous antibiotics were given preoperatively.

Surgical techniques

Over diffusely dilated and tortuous venous segments, a longitudinal incision was utilized; when repeated cannulations caused extensive erosion of the overlying skin, an elliptical incision was preferable.

You can reduce obstruction by manually compressing an AV access or by using vascular clamps or loops.

The AVF aneurysm surgical repair options included: Aneurysmorrhaphy: treating the fistula aneurysms by removing unhealthy and excessive tissues and reconstructing the vascular access lumen. A healthy, nonaneurysmal zone in the arterialized vein or the arterial anastomosis could be reached distally by dissection, provided that the anastomosis was present or included in the diffusely dilated venous segment or AVF. IV administration of heparin (5000 I.U.) before proximal and distal control of the AVF.

We used a catheter as a guide in the non-aneurysmal venous zone or at the arterial anastomosis to preserve the excess wall of the AV access after distal disconnection. Subsequently, the AVF was reconstructed over the catheter using a polypropylene longitudinal running suture. To ensure that stenosis was not present, any segments that had diffusely dilated throughout the procedure were rectified using the identical technique. We used a syringe containing saline to cleanse the vein and identify areas of leakage. We surgically resected the vein stenosis adjacent to the aneurysm through end-to-end anastomosis and managed the aneurysm according to the above procedure. When sufficient excess length resulted from venous tortuosity, a new subcutaneous tunnel was created to the distal disconnection site through an undissected area.

A tunneled hemodialysis catheter was inserted into the neck central vein at the time of the operation, when the unoperated segment was insufficient to resume dialysis from the AVF, and the incision was closed over a suction drain. After achieving effective hemodialysis through the AVF, the catheter was withdrawn. We initially attempted cannulation 4 weeks after the procedure.

Aneurysmectomy

To manage buttonholes or other tissue abnormalities over a minimally dilated fistula, the following procedures were performed: resection of the affected (scarred, necrotic) skin, suture repair of the vascular wall, and healthy margin closure of the overlying skin.

Ligation

A dialysis catheter was needed to continue hemodialysis.

RESULTS:

This interventional nonexperimental study was conducted to evaluate the different surgical modalities for the management of AV aneurysmal dilatation as a complication of AV access for dialysis in patients with ESRD on regular hemodialysis regarding the feasibility, patency, clinical success, access salvage rates, and complications (Table 1).

This table showed that the mean age of the studied patients was 49.8±12.2 years; 55.6% of them were males and 44.4% were females. The most common comorbidity was cardiac diseases (44.4%), followed by diabetes mellitus (27.8%), and then hypertension (11.1%) (Table 2).

This table showed that the mean size of the fistula was 4.2±0.7 cm with a flow of 1588.9±454.8 and time to intervention of 2.5±1.6 years. The most common sites was brachiobasilic and brachiocephalic equally (44.4%), and then radio cephalic (11.2%). Most of the fistulas were true (77.8%) (Table 3).

This table showed that most of the studied patients had no postoperative complications (72.2%), and the most common complication was thrombosis (16.7%) followed by infection and CVS (Cardiovascular system) complications (11.1%) and then recurrence in 5.6%. There were only 2 cases in need of ICU admission and the mean hospital length of stay was 2.4±1.3 days (Fig. 1, Table 4).

This table shows that the only significant variable that affected the occurrence of complications was the type of operation as no complications were detected in aneurysmectomy and end-to-end anastomosis was least detected in aneurysmectomy and graft (Table 5).

This table showed that the only significant variable that affected the patency during follow-up was the type of operation as all cases with ligation had no patency during follow-up (Fig. 2, Table 6).

This table demonstrated that there was a significantly higher operative time in patients with general anesthesia than local and regional. Also, the operative time of patients with regional anesthesia was significantly higher than local anesthesia (Table 7).

This table showed that there was only a significant linear positive association between the duration of operation and hospital stay (Fig. 3).

Table 1: Baseline characteristics of the studied patients

Characteristics	Value (*N*=18) [*n* (%)]
Age (mean±SD)	49.8±12.2
Sex	
Females	8 (44.4)
Males	10 (55.6)
Comorbidities	
DM	5 (27.8)
HTN	2 (11.1)
Cardiac	8 (44.4)

Table 2: Fistula characteristics among the studied patients

Characteristics	Value (*N*=18) [*n* (%)]
Type of fistula by site: brachiobasilic, brachiocephalic, radiocephalic	
	8 (44.4)
	8 (44.4)
	2 (11.1)
Type (true/false) false true	
	4 (22.2)
	14 (77.8)
Size (cm)	4.2±0.7
Flow (ml/min)	1588.9±454.8
Time to intervention (years)	2.5±1.6

Table 3: Intraoperative and postoperative outcomes among the studied patients

Characteristics	Value (*N*=18) [*n* (%)]
Length of operation (min)	118.1±30.5
Complications:	
No	13 (72.2)
Infection	2 (11.1)
Thrombosis	3 (16.7)
Bleeding	0
CVS or pulmonary complications	2 (11.1)
Recurrence	1 (5.6)
Need for ICU admission	2 (11.1)
Hospital length of stay (days)	2.4±1.3

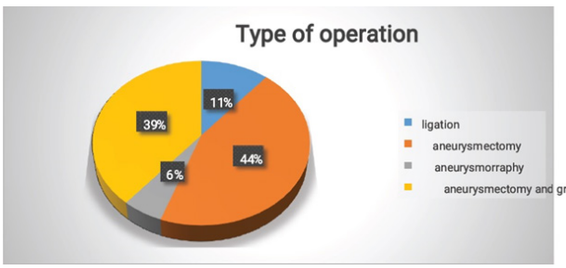

Fig. 1: Type of operation among the studied patients.

Table 4: Relationship between the presence of complications and different patients and procedure characteristics

Characteristics	No complications (*N*=5)	Complications (*N*=13)	*P* value
Age (Mean±SD)	47.2±12.7	56.6±8.6	0.152
Sex *n* (%)			
Females	6 (75.0)	2 (25.0)	0.814
Males	7 (70.0)	3 (30.0)	
Comorbidities *n* (%)			
DM	3 (60.0)	2 (40.0)	0.583
HTN	5 (62.5)	3 (37.5)	0.473
Cardiac	1 (50.0)	1 (50.0)	0.999
Type of fistula by site *n* (%)			
Brachiobasilic	5 (62.5)	3 (37.5)	
Brachiocephalic	6 (75.0)	2 (25.0)	0.555
Radiocephalic	2 (100.0)	0	
Type (true/false) false true n (%)			
	2 (50.0)	2 (50.0)	0.533
	11 (78.6)	3 (21.4)	
Size (cm)	4.2±0.7	4.5±.4	0.399
Flow (ml/min)	1576.9±426.5	1620±576.1	0.863
Time to intervention (years)	2.91±1.7	1.6±1.12884	0.127
Type of anesthesia *n* (%)			0.519
General	4 (57.1)	3 (42.9)	
Local	5 (83.3)	1 (16.7)	
Regional	4 (80.0)	1 (20.0)	
Type of operation: *n* (%)			
Ligation	0	2 (100.0)	
Aneurysmectomy	8 (100.0)	0	0.005*
Aneurysmorraphy	0	1 (100.0)	
Aneurysmectomy and graft	5 (71.4)	2 (28.6)	
Length of operation (min)	114.2±29	128±35.6	0.408
Need for ICU admission *n* (%)			
No	13 (81.3)	3 (18.8)	0.065
Yes	0	2 (100.0%)	
Hospital length of stay (days)	2.5±1.3	2.2±1.6	0.722
Follow-up patency *n* (%)			0.172
No	1 (33.3)	2 (66.7)	
Yes	12 (80.0)	3 (20.0)	

**P value* is significant.

Table 5: Relationship between the patency on follow-up and different types of patients and procedure characteristics

Characteristics	Not patent (*N*=3) [*n* (%)]	Patent (*N*=15) [*n* (%)]	*P* value
Age (mean±SD)	52.7±21.3	49.3±10.7	0.675
Sex			
Females	2 (25.0)	6 (75.0)	0.559
Males	1 (10.0)	9 (90.0)	
Comorbidities			
DM	2 (40.0)	3 (60.0)	0.172

HTN	3 (37.5)	5 (62.5)	0.69
Cardiac	0	2 (100.0)	0.686
Type of fistulas: brachiobasilic brachiocephalic radiocephalic			
	2 (25.0)	6 (75.0)	0.538
	1 (12.5)	7 (87.5)	
	0	2 (100.0)	
Type (true/false) false true			0.108
	2 (50.0)	2 (50.0)	
	1 (7.1)	13 (92.9)	
Size (cm)	4±0.8	4.3±0.7	0.588
Flow (ml/min)	1800±346.4	1546.7±471.8	0.395
Time to intervention (years)	1.3±1.4	2.7±1.6	0.156
Type of operation:			
Ligation	2 (100.0)	0	0.010*
Aneurysmectomy	0	8 (100.0)	
Aneurysmorraphy	0	1 (100.0)	
Aneurysmectomy and graft	1 (14.3)	6 (85.7)	
Length of operation (min)	100±20	121.7±31.4	0.275
Type of anesthesia			
General	2 (28.6)	5 (71.4)	0.424
Local	1 (16.7)	5 (83.3)	
Regional	0	5 (100.0)	

**P value* is significant.

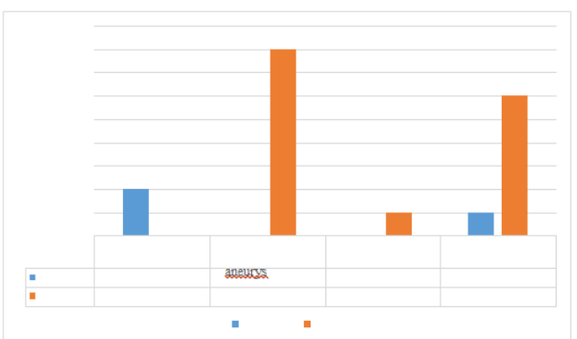

Fig. 2: Relationship between patency and type of operation.

Table 6: Relationship between the type of anesthesia and the operative time and hospital length of stay

	N	Mean	SD	*P* value
Hospital stay duration (days)				
General	7	3.29	1.704	**0.059**
Local	6	1.67	0.516	
Regional	5	2.00	0.707	
Duration of operation (min)				
General	7	138.57	27.343	0.044*
Local	6	98.33	14.720	
Regional	**5**	**113.00**	**34.928**	

Table 7: Correlation between intraoperative time and hospital length of stay and different independent variables

Independent variables	Duration of operation (min)	Hospital length of stay (days)
Hospital length of stay (days)		
Correlation coefficient (r)	0.633**	–
P value	0.005	
Age		
Correlation coefficient (r)	–0.040	–0.262
P value	0.874	0.294
Size (cm)		
Correlation coefficient (r)	0.339	0.142
P value	0.168	0.574
Flow (ml/minute)		
Correlation coefficient (r)	0.280	0.298
P value	0.261w	0.229
Time to ttt		
Correlation coefficient (r)	0.202	0.334
P value	0.422	0.176

**P value* is significant.

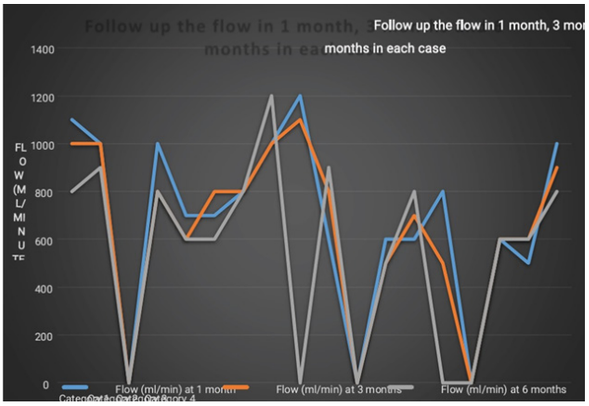

Fig. 3: Follow-up the flow of fistula at 1, 3, and 6 months in each case.

Case No. 1

A 50-year-old male patient, hypertensive and diabetic, with ESRD on regular hemodialysis for the past 7 years, but without a known cardiac condition.

Access history

First AVF was right radio cephalic access, which functioned well initially. Three years ago, this access developed two focal aneurysmal dilatations that gradually progressed. Then multiple aneurysms were eroding the skin overlying, painful for the patient, shortening the cannulation area, and led to cosmetic disfigurement.

Complaint

Pain in the left arm, no more efficient dialysis session as before, and no more cannulation segment for usage.

Physical examination

General: vitally stable; no lower limb edema. Local: multiple focal aneurysmal dilatations of the venous segment in the right forearm until the elbow with discolored and thin skin overlying the AVF. Thrill was well felt; there were no signs of infection (Fig. 4).

Fig. 4: Left-sided: skin overlying multiple aneurysms eroded.

Right sided

Longitudinal incision, Dissection meticulously, and clamping proximally and distally.

Management

General anesthesia, supine position with right upper limb abducted. Preoperative antibiotics was administered. Longitudinal incision was preferred over multiple dilated fistula aneurysms. Dissection meticulously to the venous segment till AV anastomosis after heparin administration; proximal and distal clamps were performed. Resection of the two venous aneurysmal lesions (aneurysmectomy), then partial aneurysmectomy and aneurysmorraphy to the venous wall with 6-0 Polypropylene sutures. Clamps were released; well-felt thrill was confirmed before the closure of the skin. Postoperative antibiotic patients were transferred to the ward 2 days after the patient was discharged from the hospital (Fig. 5).

Fig. 5: Partial aneurysmectomy (PAR) and aneurysmorraphy and then closure of overlying healthy skin without drain. The first postoperative visit occurred within 1–2 weeks to assess the healing of the incision. The sutures were typically removed 2 weeks after repair.

DISCUSSION

On average, the mean age was 55.5 years. The case group was predominantly male, with the percentage of males varying from 53% to 79%[10]. The present investigation revealed that the average age of the cases in the investigation was 49.8±12.2 years. Among the cases, 55.6% were men and 44.4% were women.

Treatment indications as defined by Balaz and Bjorck were included in all studies, except for one. In all, 53 (10%) cases were assigned to group C, 513 (86%) to group A, and 21 (4%) to group B. Bleeding prevention was the prevalent indication for surgical treatment, accounting for 86% of cases[11]. But in this

study, the most common indication for intervention was skin erosion (66.7%), followed by shortness of potential cannulation area (44.4%), multiple aneurysms or massive diffuse venous dilatation (33.3%), local pain and steal syndrome (22.2%), outflow vein stenosis, and high inflow pressure (11.1%).

According to Balaz and Bjorck, the treated aneurysms varied in diameter from 15 to 80 mm. In most investigations, the duration between the creation of an AVF and its treatment was quantified, ranging from 1 year for the shortest case to 12 years for the longest[11].

This study demonstrated that the mean diameter of the fistula was 42±7 mm with a flow of 1588.9±454.8, which was the same average size and flow as in the previous studies, and the time to intervention was 2.5±1.6 years.

Of the cases, 59% showed aneurysms in the upper arms, followed by fistulae in the forearm (41%)[12].

Only 3% of the cases encountered early postoperative complications within the initial 30 days following the procedure. Hemorrhagic complications were the most prevalent, occurring in 2% of cases. Two (0.3%) cases experienced acute thrombosis, while 1 (1%) case, who had undergone aneurysm repair with an external prosthesis, developed graft infection[10].

In all, 7% of patients suffered late complications following surgery (lasting longer than 30 days).

Exoprosthesis-related late infections (3%), late thromboses (1%), and skin necrosis (0.2%) occurred. The aggregated complication rate was 11%. The incidence of complications was comparable in both aneurysmologies conducted with and without external prosthetic reinforcement (seven percent each) when a stapler was used (4%)[10].

This study demonstrated that most of the studied cases had no postoperative complications (72.2%), and the most common complication was thrombosis (16.7%), followed by infection and CVS complications (11.1%), and then recurrence (5.6%).

A frequently discussed issue is the need for temporary central venous catheter insertion to allow the repaired aneurysm to fully recover before application. Seven studies used central catheters for hemodialysis for 4 weeks after the operation. Conversely, in the remaining studies, dialysis was conducted immediately following the operation through the repaired fistula[10].

In 2020, Balaz and colleagues demonstrated that the average duration of procedures across six investigations varied between 130 and 188 min, with a pooled mean of 146 min[10]. However, this study showed that the mean procedure time was 118.1±30.5 min. There was a significantly higher operative time in patients with general anesthesia than in local and regional. Also, the operative time of patients with regional anesthesia was significantly higher than that with local anesthesia.

By pooling these mean values, an overall mean hospital stay of 1.8 days was obtained. The investigation conducted by Moskowitz *et al*.[13] on aneurysmography was performed in an outpatient setting. In this study, the mean hospital stay was reported as 2 days.

This study showed that the only significant variable that affected the occurrence of complications was the type of operation, as no complications were detected in aneurysmectomy and end-to-end anastomosis, but complications were detected in aneurysmectomy and graft.

During the follow-up period of 16.5 months (IQR: 14–20.5 months) in the research conducted by Tozzi *et al*.[14], no case was lost; therefore, the total number of cases at 12 months was calculated using the number of cases involved at the outset of the research.

The duration of follow-up in the research conducted by Nezakatagoo *et al*.[15] ranged from 7 to 95 months, and despite the possibility that a small percentage of patients had not been monitored for a full year, the decision was made to include all patients from this cohort. The research by Piccolo *et al*.[16] did not document patency until the sixth month.

Every other study either reported primary patency at the 12-month mark or calculated it. At 12 months, the aggregated primary patency rate was 82%. The 12-month primary patency rates for aneurysmorrhaphy treated with external prosthetic reinforcement (85%, 95%), stapler-assisted aneurysmorrhaphy (74%, 95%), and unassisted aneurysmorrhaphy (82%, 95%) were identical.

The patency rate was not reported until 6 months into this research; it was 83.3% after 1 month and 72.2% after 3 and 6 months.

All studies involved in the patency analysis reported primary patency for a minimum of 12 months following aneurysms, except for one. At 12 months, the aggregated primary patency rate was 82%. Nevertheless, a possibility of publication bias was detected in the documentation of primary patency rates, and lesser rates of primary patency may be observed in clinical practice. Except for the study by Wang and Wang[17], which reported primary patency of 45% at

1 year, 12 of the studies included in the assessment of primary patency reported primary patency among 67% and 100%. In contrast, primary assisted patency was elevated significantly in the study previously noted.

Of the patients, 96% maintained their patency 1 year after endovascular patency maintenance procedures. The potential cause for the relatively low primary patency observed in the study conducted by Wang and Wang[17] could be attributed to the stringent criteria for endovascular procedures after fistulography for stenoses exceeding 50%. 22 In two investigations, reinforced aneurysmography was used[18,19].

With a recurrence rate of under 3%within 1 year, aneurysmotherapy seems to be a risk-free procedure for aneurysm recurrence[18].

CONCLUSION

The different surgical modalities for the management of AV aneurysmal dilatation as a complication of AV access for dialysis in patients with ESRD can be used safely with good clinical success to salvage VARA with minimal complications; the least was detected to be related to aneurysmoetry, followed by aneurysmectomy with an interposition graft.

We recommend treating the underlying stenosis endovascularly once we confirm the central vein stenosis. Asymptomatic aneurysmal fistulae are ultimately best managed with conservative treatment.

Regular, strict, meticulous, and longer follow-up plans are recommended to survey the long-term outcomes of different surgical modalities.

CONFLICT OF INTEREST

There are no conflicts of interest.

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