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Original Article

Endovascular Management of Arterial Injuries Related to Venous Access: A Retrospective Review of 10-Year Single-Center Experience

Abstract

Purpose: Retrospective review of the pattern and management techniques of arterial injuries related to central venous access with long-term outcomes. **Materials and Methods:** Between January 2007 and November 2017, a total of 20 patients (13 females) were included with the mean age of 63 (28–89 years) and mean body mass index of 25.75 (13.3–36.5). Venous access procedures included central venous catheter (CVC) placement, dialysis line insertion, or endovascular venous procedures. The study excluded patients who had arterial injuries related to arterial access, such as postarterial line placement, postangiography, or percutaneous coronary interventions. **Results:** Iatrogenic arterial injuries occurred after attempted venous access procedures involving the common femoral vein (n = 18) and subclavian vein (n = 2). Injuries were related to CVC placement (n = 5), temporary dialysis catheter (n = 14), and inferior vena cava filter insertion (n = 1). Nine patients had transarterial venous catheter insertion complicated by active bleeding from pseudoaneurysm and arteriovenous fistula. Other injuries included isolated fistula (n = 3), isolated pseudoaneurysm (n = 4), isolated branch injury (n = 2), and intra-arterial insertion (n = 2). Endovascular management included stent–graft placement (n = 14), embolization of bleeding vessel (n = 2), and thrombin injection for pseudoaneurysm (n = 2). Conservative management with manual compression achieved hemostasis in two patients. Technical success was achieved in 100%. One patient required repeat angiography and embolization of bleeding branch vessel following stent–graft placement to control bleeding fistula and pseudoaneurysm. Clinical success was achieved in all patients. Procedure-related complications included puncture site hematoma (n = 1) and partially occlusive thrombus/spasm of deep femoral artery after stent–graft placement. Six patients (33%) died within 20 days after the procedure (3–20 days) due to other comorbidities. Three additional patients (16%) died during the same hospital admission at the time of the procedure (38–114 days). There were no reported complaints related to possible stent–graft stenosis or occlusion at mean follow-up time of 5 years (50 days–8.64 years) in all seven patients who survived after stent–graft placement procedure. **Conclusion:** Despite technically successful endovascular management of arterial injuries related to venous access in critically ill patients, the mortality rate remains high due to other comorbidities. Allowing for the small sample size, stent–graft placement for arterial injuries in this cohort of patients appears to be an effective option with high long-term patency rate.

Keywords: *Arterial injuries, central venous catheters, embolization, stent graft, venous access*

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Introduction

Central venous access is an essential adjunct in patient management in both emergency and elective situations. Central venous catheter (CVC) insertion is performed by various medical and surgical specialties leading to significant variations in techniques, expertise and subsequently the rate of complications. Although ultrasound guidance for central venous access helps in reducing the rate of complications, these procedures are still being performed blindly using manual palpation and anatomical landmarks for reference. Previous radiotherapy or surgery at the site of venous access, lack of expertise, obesity, and multiple attempts at cannulations are important predictive risk factors for CVC-related vascular complications. Without ultrasound guidance, the incidence of arterial punctures is as high as 15%.[1-7] With image guidance, the complication rate falls to 1%.[2-7] The incidence of arterial injury is higher in internal jugular vein puncture compared to subclavian puncture (6% vs. 0.5%–4%).[1,8,9] Thirty percent of arterial punctures during CVC insertion can result in hematomas that can potentially expand and obstruct the

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airway, cause hemothorax impairing respiratory excursion and neurological deficits.[1,9] Other complications include pseudoaneurysms, dissection, arteriovenous fistulas (AVF), limb ischemia, and death. Management ranges from manual compression after removal of CVC to open surgical techniques.[2,9,10] However, endovascular repair including the off-label use of percutaneous arterial closure devices, stent grafts, and balloon tamponade have emerged as treatment options with factors such as the anatomical location of the injury, the hemodynamic status of the patient, and local availability of expertise determining the technique adopted to rectify the arterial injury and its consequences.[10-15] This study aims to identify the pattern and management techniques of arterial injuries related to central venous access with long-term outcomes. We also propose a classification system and management algorithm to approach these patients with suspected arterial injury following CVC insertion.

Materials and Methods

The institutional review board approved this retrospective study and informed consent from patients was obtained. The radiology information system was screened for patients who underwent percutaneous or endovascular management for arterial injuries related to venous access between January 2007 and November 2017. Venous access procedures included CVC placement, dialysis line insertion, or endovascular venous procedures. The study excluded patients who had arterial injuries related to arterial access procedures, such as postarterial line placement, postangiography or percutaneous coronary interventions. All patients were in critical condition and were deemed not suitable candidates for surgery at the time of referral to interventional radiology. The study team did not search the databases for patients who had surgical repair or conservative management without interventional radiology referral. A total of 20 patients (13 females) were included with the mean age of 63 (28–89 years) and mean body mass index of 25.75 (13.3–36.5). All venous access procedures, but one, were performed at bedside by the primary team. The exact mode of guidance during insertion procedures could not be determined from charts review. Patients were evaluated for the type of venous procedure, type and location of arterial injury, clinical presentation, endovascular management, technical and clinical outcomes as well as procedure-related complications. Types of arterial injuries included pseudoaneurysm, branch injury, AVF, and inadvertent intra-arterial line insertion. Technical success was defined as the successful angiographic control of bleeding, isolation of fistula, or complete obliteration of pseudoaneurysm. Clinical success was defined as achieving hemostasis or resolution of fistula-related symptoms. Patients who had stent placement for fistula or bleeding management were evaluated for stent-related complications at last clinical follow-up. Procedure-related complications were evaluated based on the Society of Interventional Radiology classification system.

Results

Iatrogenic arterial injuries occurred after attempted venous access procedures involving the common femoral vein (n = 18) and subclavian vein (n = 2). Injuries were related to CVC placement (n = 5), temporary dialysis catheter (n = 14), and inferior vena cava filter insertion (n = 1). Nine patients had transarterial venous catheter insertion complicated by active bleeding from pseudoaneurysm and AVF. Other injuries included isolated fistula (n = 3), isolated pseudoaneurysm (n = 4), isolated branch injury (n = 2, inferior epigastric and deep femoral arteries), and intra-arterial insertion (n = 2). The superficial femoral artery (SFA) was injured in 10 patients (50%) with fistula and pseudoaneurysm formation in 9 of these cases and isolated pseudoaneurysm in the remaining patient. Deep femoral artery to femoral vein fistula was seen in 3 cases with associated pseudoaneurysm formation (n = 2). Injuries to the common femoral artery included isolated pseudoaneurysm (n = 3) and isolated fistula (n = 1). Two patients had intra-arterial line insertion of venous catheter (1CVC and 1 dialysis line) into the subclavian arteries [Table 1]. Injuries were suspected either after attempted insertion or after removal of dialysis catheters that were placed inadvertently through the artery. Two patients with intra-arterial catheter insertion into the subclavian arteries had their lines removed immediately before stent–graft placement. One patient had a 7 Fr CVC traversing the SFA on computed tomography (CT) angiography, and the catheter was removed with manual compression after angiographic confirmation of fistula. Patients presented with active bleeding in 50% (n = 10), expanding pseudoaneurysm (n = 6), fistula-related heart failure (n = 1) and bruit (n = 1), and misplaced venous line into the artery (n = 2). Management of arterial injuries is summarized in Tables 2 and 3 based on involved vessels and types of injuries. This included stent–graft placement (n = 14) with either GORE® VIABAHN® Endoprosthesis (W. L. Gore and Associates, Inc., AZ, USA) or Fleuncy® (BARD Peripheral Vascular, Inc., AZ, USA). Other patients were managed with embolization of bleeding vessel (n = 2), thrombin injection for pseudoaneurysm (n = 2), and by compression (n = 2).

Table 1: Types of injuries based on anatomical location

	Fistula + PSA	Fistula	PSA	Arterial insertion	Bleeding
SFA	9		1		
CFA		1	3		
DFA	2	1			
Branch injury		1			2
Subclavian				2	

PSA: Pseudoaneurysm, SFA: Superficial femoral artery, CFA: Common femoral artery, DFA: Deep femoral artery

Technical success was achieved in 100%. One patient required repeat angiography and embolization of isolated branch following stent–graft placement to control bleeding fistula and pseudoaneurysm. Clinical success was achieved in all patients. Procedure-related complications included puncture site hematoma (*n* = 1), partially occlusive thrombus/spasm of deep femoral artery after stent–graft placement. All complications were managed without additional interventional procedures. Six patients (33%) died within 20 days after the procedure (3–20 days) due to other comorbidities. Three additional patients (16%) died during the same admission of the procedure (38–114 days). There were no reported complaints related to possible stent–graft stenosis or occlusion at mean follow-up time of 5 years (50 days–8.64 years) in all seven patients who survived after stent–graft placement procedure.

Discussion

Early recognition of arterial injuries is paramount to minimize the consequences of these complications. Cross-section imaging with CT angiography is essential in identification of the type and site of injury. While surgical repair may be the optimal method for the management of superficial and easily accessible arterial injuries such as the carotid or femoral arteries, endovascular approach is less invasive and more suitable for injuries that are difficult to surgical access such as the subclavian arteries or in critically ill patients. In a systematic review of 80 cases of arterial injuries related to venous access, endovascular management was successful in 94.6% of cases and surgical repair achieved 100% success rate. Catheter removal and compression failed in controlling bleeding and its complications in nearly 94%.[12] Endovascular approach depends on the type and site of injury and whether the wire/catheter is in place at the time of injury recognition as previously proposed by Guilbert *et al*.[13]

This study identifies three different patterns of arterial injuries related to venous access and we propose the following classification and algorithm as a guide for endovascular management of such injuries [Chart 1].

Type 1: Branch artery injury, such as the inferior epigastric artery [Figure 1] or deep femoral artery, is likely related to needle injury during the attempted insertion. This may present with expanding hematoma or contained pseudoaneurysm. This often requires embolization or percutaneous thrombin injection, respectively.

Type 2a: Main arterial injury with wire/dilator/catheter in place. This is commonly encountered in the common femoral, subclavian [Figure 2] or carotid arteries, and rarely in the brachiocephalic or thoracic aorta. While manual compression may be sufficient to manage wire injuries in superficial vessels, insertion of large-bore catheters or cannulation of deep vessels may require additional surgical or endovascular measures to prevent major complications such as expanding hematoma, hemothorax, airway compression or stroke. Endovascular options include the

Table 2: Endovascular management of arterial injury based on anatomical location

	Stent graft	Embolization	Thrombin	Compression/ conservative
SFA	8		1	1
CFA	2		1	1
DFA	2	1		
Inferior epigastric		1		
Subclavian	2			

SFA: Superficial femoral artery, CFA: Common femoral artery, DFA: Deep femoral artery

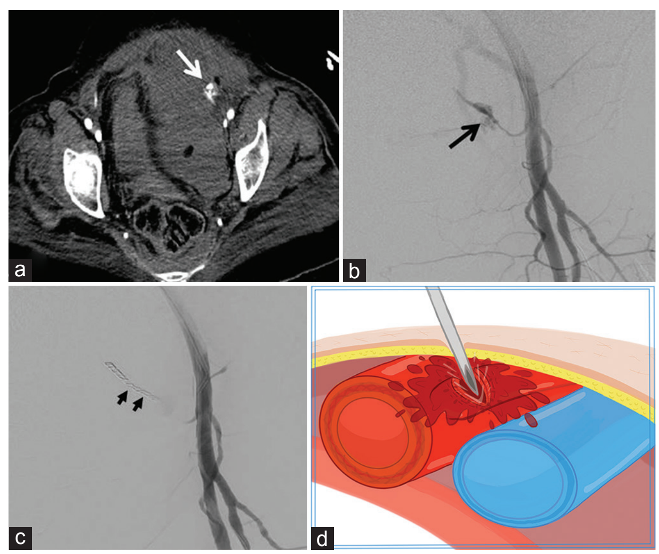

Figure 1: (a) Computed tomography angiogram showing active extravasation from the left inferior epigastric artery (white arrow). (b) Angiography showing the bleed from the proximal part of the inferior epigastric artery (black arrow). (c) Postcoil embolization angiography (black arrows). (d) Schematic illustration of Type 1 side branch arterial injury

Table 3: Endovascular management of arterial injury based on type of injury

	Stent graft	Embolization	Thrombin	Compression/conservative
PSA	2		2	
Fistula	3			
Fistula and PSA	6	1		2
Arterial insertion	2 (1 attempted starclose)			
Isolated branch injury		2		

PSA: Pseudoaneurysm

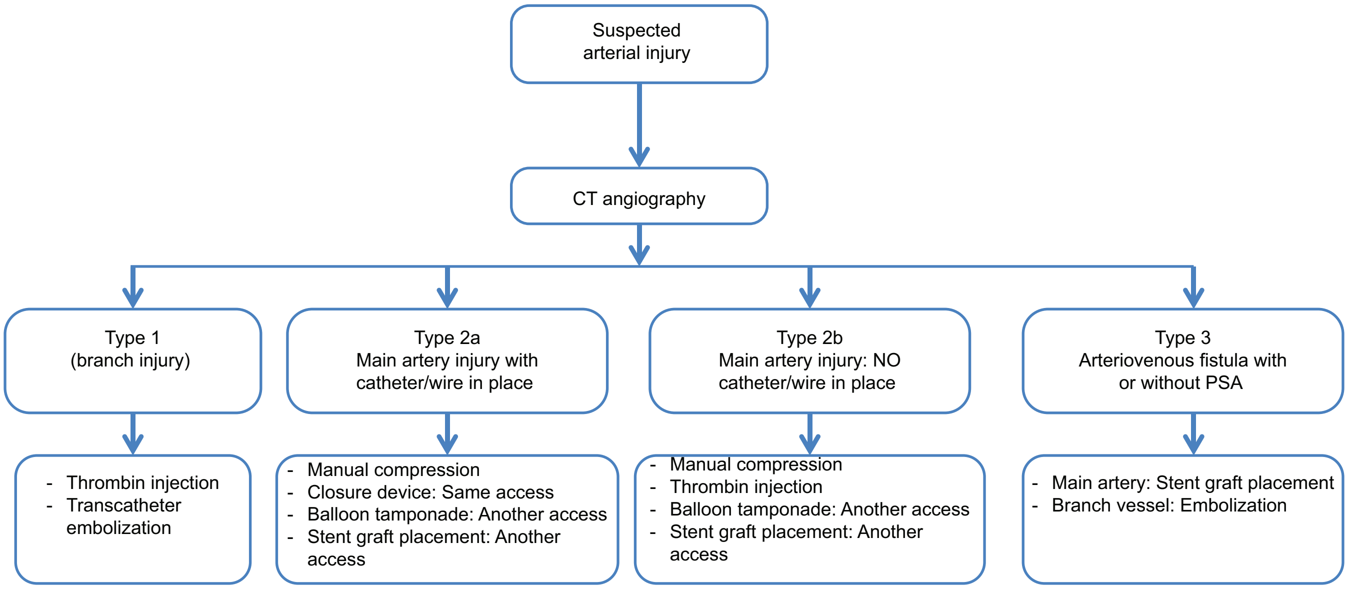

Chart 1: Proposed classification and algorithm for the endovascular management of arterial injuries related to venous access

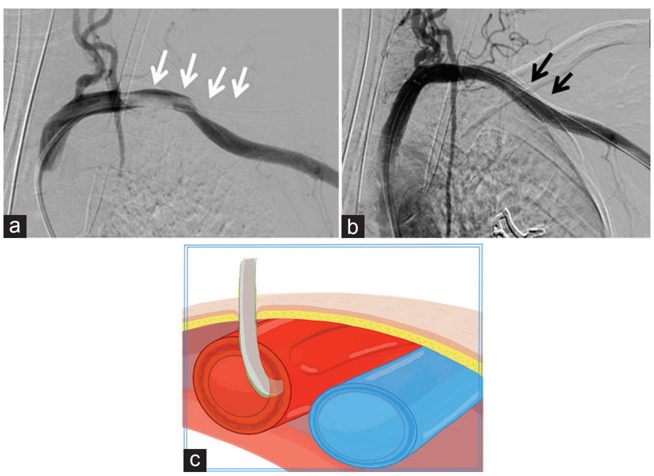

Figure 2: (a) Angiography showing a temporary dialysis catheter in the left subclavian artery (white arrows), (b) the arterial entry point was sealed with a stent–graft placement (black arrows). (c) Schematic illustration of Type 2a arterial injury with catheter in place

use of closure devices such as Angio-Seal or Proglide using the same access.[11,14-17] Alternatively, another access is required to perform temporary balloon occlusion[10,11,17] or stent–graft placement.[10-13,15,17,18]

Type 2b: Main arterial injury with no device in place; this type is likely related to needle injury or may be recognized by the pulsatile flow after insertion of dilator or catheter [Figure 3]. Manual compression may be sufficient to manage this type of injury in superficial vessels if immediately recognized. However, additional endovascular methods are required in deep vessels or when complicated by bleeding. The use of closure devices in this type is not feasible, and endovascular management involves temporary balloon occlusion or stent–graft placement. Thrombin injection is another treatment option in cases of pseudoaneurysm [Figure 4].

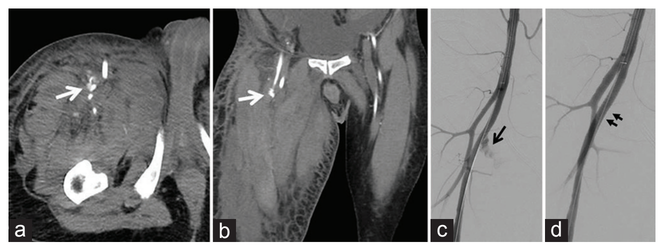

Figure 3: (a) Axial and (b) coronal computed tomography angiogram showing active extravasation from the right superficial femoral artery (white arrows) with no catheter in place. (c) Angiography showing the bleed from the proximal superficial femoral artery (black arrow). (d) Arterial injury was treated stent–graft placement (black arrows)

Type 3: AVF, with or without pseudoaneurysm, is most commonly encountered in SFA and likely related to transarterial insertion of large-bore dialysis catheters [Figure 5]. This injury is often diagnosed few hours or days after insertion following removal of the, otherwise properly functioning, venous catheter. Due to the direct fistula and involvement of both anterior and posterior arterial walls, the use of manual compression or closure devices is unlikely to fix the injury. This type often requires stent–graft placement to repair the fistula and isolate the pseudoaneurysm.

In our series, only 3 patients had their catheters in place. Two of them had intra-arterial insertion of catheter in the subcalvian artery, which were managed by stent–graft placement. The third patient had catheter removal and manual compression after angiographic confirmation of transarterial venous catheter insertion resulting in fistula formation [Figure 6]. Although there was no bleeding complication, asymptomatic persistent fistula was detected on follow-up ultrasound.

While endovascular management was technically and clinically successful in our series, arterial injuries are

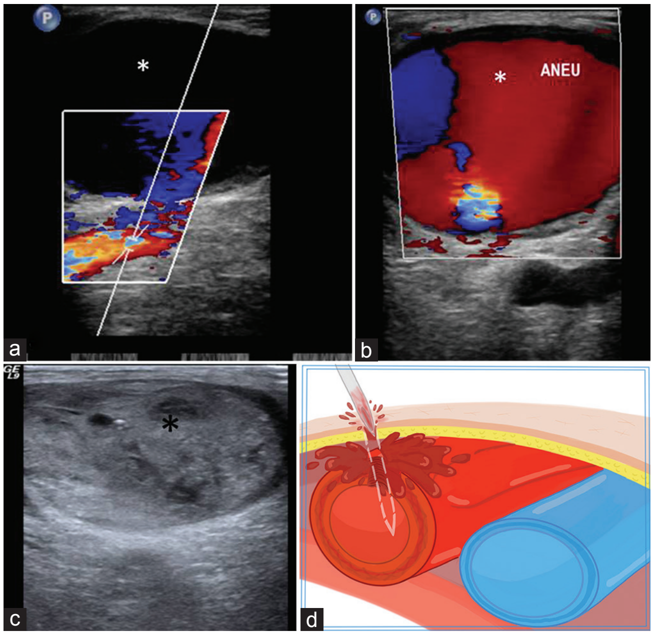

Figure 4: (a and b) Color ultrasound of the right common femoral artery showing the pseudoaneurysm (white stars), (c) treated with thrombin injection (black star). (d) Schematic illustration of Type 2b main arterial injury with no catheter or wire in place

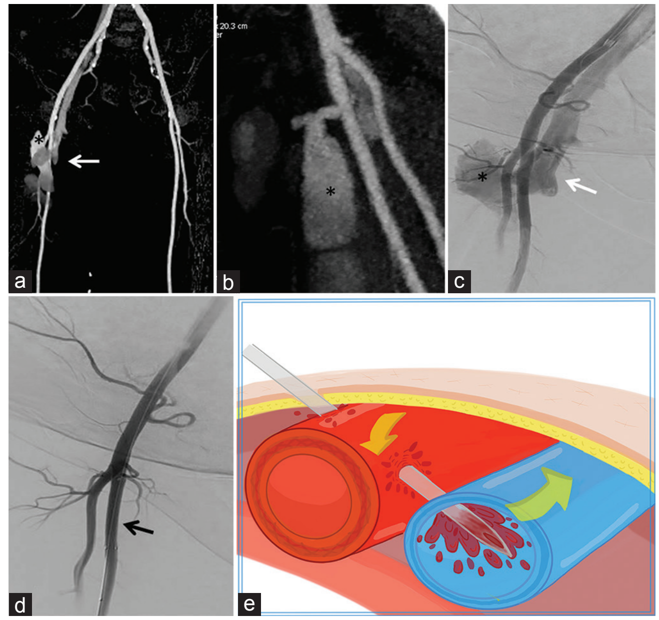

Figure 5: Three-dimensional computed tomography (a and b) and conventional angiography (c) showing pseudoaneurysm from the right superficial femoral artery (black stars) with arteriovenous fistula (white arrows), (d) the arterial injury was treated with stent–graft placement (black arrow). (e) Schematic illustration of Type 3 arterial injury with arteriovenous fistula

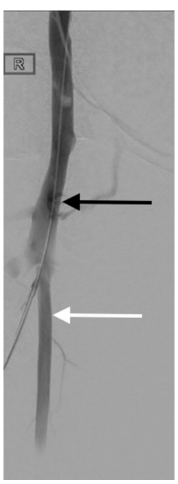

Figure 6: Pullback angiography shows simultaneous filling of the superficial femoral artery (white arrow) and femoral vein (black arrow) in keeping with arteriovenous fistula

associated with high-mortality rate approaching 50% due to other comorbidities in these critically ill patients. This highlights the importance of using ultrasound guidance to reduce the rate of arterial injuries and prevent their potential consequences. In addition, the use of stent grafts carries additional risks of thrombosis, intra-stent stenosis or fractures and may necessitate the use of anticoagulants to maintain long-term patency. While there were no reported complications related to stent–graft placement during the study period, we were unable to determine the protocol of anticoagulation in those patients.

This study spans the transition period between paper and electronic medical records and is inherently limited by its retrospective nature and missing data related to baseline anticoagulation and postprocedural anticoagulation protocols. The exact interval between catheter insertion and recognition of injury as well as the method of guidance could not be identified from chart review.

Conclusion

Despite the technically successful endovascular management of arterial injuries related to venous access in critically ill patients, mortality rate remains high due to other comorbidities. Allowing for the small sample size, stent–graft placement for arterial injuries in this cohort of patients appears to be an effective option with high long-term patency rate.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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