Original Research

Management of Early and Late Detected Vascular Complications Following Femoral Arterial Puncture for Cardiac Catheterization

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Catheterization, vascular complication, iatrogenic trauma.

Introduction: Iatrogenic vascular trauma is more frequent today as a result of the increase in diagnostic and therapeutic femoral catheterizations. Management of related complications is elective or urgent and sometimes needs complex vascular reconstruction. The present study evaluated when and whether conservative, urgent surgical, or elective surgical treatment is appropriate.

Methods: A retrospective analysis was made of 45 consecutive iatrogenic vascular trauma patients, among 10,450 cardiac diagnostic or therapeutic catheterizations. Patients' demographics, type of catheterization, time from catheterization to initial diagnosis, the type of complication (thrombosis, infection, bleeding, pseudoaneurysm, etc.), time from presentation of the complication to definite treatment, diagnostic imaging and decision making, the surgical or conservative management, the length of stay and the clinical outcome were determined and analyzed.

Results: We identified and treated 30 early and 15 late (after patient's discharge) arterial complications: 18 pseudoaneurysms, 6 bleedings, 9 hematomas, 5 deep vein thromboses, 3 arteriovenous fistulas, 2 arterial embolisms and 2 arterial thromboses. Eight patients underwent emergency surgical repair, three elective surgical repair and 31 were managed conservatively. Decision making was based only on clinical evaluation in 12 patients, whereas vascular ultrasound was the most frequent diagnostic imaging modality in the remainder. A total of 10 (22.2%) minor secondary complications were identified after the initial management with no limb loss and zero mortality.

Conclusions: Close clinical observation and conservative management of vascular trauma complications resulted in a low incidence of the necessity for surgical repair (25% of cases). Bleeding and acute leg ischemia were the most frequent indication for emergency surgical treatment, whereas the majority of pseudoaneurysms, fistulas and vein thrombosis were successfully treated conservatively. Late vascular complications do occur and add an important morbidity factor to early catheterization complications.

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Cardiac angiography via percutaneous catheterization of the femoral artery causes a iatrogenic arterial trauma. There is an extensive and increasing body of knowledge concerning retrospective series and reviews of iatrogenic arterial trauma, which is related to the increasing diagnostic and therapeutic use of percutaneous endovascular techniques.[1-9] Manual compression is the cornerstone of initial management of bleeding, whereas percutaneous closure devices provide an

alternative option. However, early and late vascular complications do occur with either technique.[10] Prompt diagnosis and management are critical, since vascular complications threaten limb viability, while vascular surgical reconstruction, when needed, is a major factor contributing to the increased mortality of the critically ill group of cardiac patients. Although early in-hospital femoral vascular complications have been extensively studied, the incidence and types of late vascular complications after hospital discharge have not been well defined.

We evaluated early and late femoral artery trauma after femoral catheterization in a large group of patients who underwent cardiac imaging for diagnostic and therapeutic purposes in a university hospital in Athens, Greece. The purpose of this retrospective study was to evaluate the nature, management and outcomes of vascular complications following femoral artery catheterization and manual compression. The determination of differences in early and late vascular complications and their clinical significance in terms of outcome was a secondary aim. We describe our surgical and conservative management of these complications and the overall algorithm for decision making.

Patients and methods

This is a retrospective review of all peripheral vascular complications after femoral artery catheterization for cardiac imaging, performed in either of the two departments of cardiology in a tertiary university hospital between June 2004 and June 2006. All patients had retrograde transcutaneous femoral artery cardiac catheterization for diagnostic and/or therapeutic purposes. Only patients referred to the vascular surgery department of the same hospital for consultation for a vascular complication were included. The following data were collected and analyzed for each patient: patients' demographics, type of catheterization, time from catheterization to initial diagnosis, type of complication (thrombosis, infection, bleeding, pseudoaneurysm, etc.), time from presentation of the complication to definite treatment, diagnostic imaging and decision making, the surgical or conservative management, length of stay and clinical outcome.

Entry criteria and diagnostic evaluation

During the 2-year period, 10,450 femoral cardiac catheterizations were performed in the two cardiology departments. All patients were hospitalized for at least one day after the procedure. The resident cardiologist evaluated all patients clinically after discharge from the cardiac catheterization suite, at one hour and every hour thereafter until femoral sheath removal, and then every three hours until the next day. Sheath removal was followed by manual compression in a standard manner. Before the patient's discharge from hospital, the attending cardiologist who performed the catheterization evaluated the patient for bleeding, hematoma, pseudoaneurysm, leg edema, presence of femoral pulses and pulses at ankle level. If peripheral pulses were absent the same physician evaluated arterial flow with a hand-Doppler machine. In case of 1) extensive or extending hematoma, 2) bleeding or drop of hematocrit by more than 5 units, 3) pseudoaneurysm, 4) leg ischemia, or 5) leg edema and probable deep vein thrombosis, the patient was referred to the division of vascular surgery of the hospital. All these cases were classified as early vascular complications. Almost all patients who were discharged from hospital without signs or symptoms of vascular complication had a subsequent visit for cardiac reevaluation after at most 6 months. Any vascular complication mentioned on this visit, or at any other time after hospital discharge, which was referred to the division of vascular surgery of our hospital was classified as a late vascular complication.

Results

A total of 45 patients with post-catheterization vascular complications were identified. Of these, 25 (55%) underwent therapeutic and the remainder diagnostic catheterization.

Mean age was 64 years, while male to female ratio was 1.6 (Table 1). The average time from procedure to identification of the vascular complication and initialization of treatment was 6 days (range 1-23), while early detected complications constituted 66% of the total. Primary findings at presentation of the complication included pulsatile groin mass (n=18, 40%), hematoma (n=9, 20%), hemorrhage (n=6, 13.3%), lower extremity ischemia (n=4, 8.9%), murmur in the groin area (n=3, 6.7%), and edema of the limb (n=3, 6.7%). Vascular ultrasound was used for diagnostic imaging in 28 patients, while in 2 patients an abdominal computed tomography scan was deemed essential for determination of the extension of retroperitoneal hematomas (Figure 1); in another 3 patients digital subtraction angiography was performed in order to establish a definite diagnosis and

Table 1. Demographics of all patients with vascular complications.

Age (yrs.)	
> 60	29 (64.4%)
< 60	16 (35.6%)
Mean	63
Sex	
Male	28 (62.2%)
Female	17 (37.8%)
Purpose of cardiac catheterization	
Therapeutic	25 (55.5%)
Diagnostic	20 (44.5%)

plan treatment (two cases of large pseudoaneurysms and one case of leg ischemia). In 12 patients, treatment was planned after only clinical evaluation (without additional imaging), based on either the emergent clinical course of the vascular complication (hemorrhage or severe leg ischemia) or the fact that the clinical diagnosis was clear and there was no need for any further diagnostic imaging (arteriovenous fistulas).

After all diagnostic methods had been applied, we identified 18 cases with pseudoaneurysm (40%), 6 patients with bleeding (13.3%), 9 cases with hematomas (20%), 3 cases with arteriovenous fistulas (6.6%), 5 cases with deep venous thrombosis (11.1%), 2 patients with arterial embolism (4.44%) and 2 patients with arterial thrombosis (4.44%) (Table 4). There were 8 cases (17.7%) that underwent emergency surgical repair (4 patients with acute limb ischemia, 3 patients with persistent and relative massive hemorrhage and 1 patient with extending hematoma and a drop in hematocrit). Three cases were managed on an elective surgical basis (1 patient with arteriovenous fistula and 2 patients with pseudoaneurysms). The rest of the complications (75% of all cases) were managed conservatively (9 hematomas, 5 deep venous thromboses, 16 pseudoaneurysms, 2 bleedings, and 2 arteriovenous fistulas) (Tables 2-4). Conservative treatment used in these series included: a) modification or cessation of antithrombotic treatment, b) fresh frozen plasma or blood transfusions as required, c) manual compression at bleeding point or hematoma, d) compression of pseudoaneurysms under ultrasound guidance, e) antibiotic treatment in the case of hematomas with risk of infection (diabetics, immune suppressed, prosthetic valve), and f) absolute bed rest.

Figure 1. Right retroperitoneal hematoma (white arrows), which remained stable and was managed conservatively (blood transfusion, discontinuation of antithrombotic medication) with success.

The average pseudoaneurysm size was 4.4 cm (range 2.0-7.4) in greatest dimension. Ultrasound scanning with manual compression was used in 15 patients with pseudoaneurysms to heal the communication and thrombose the aneurysm. This was done successfully in 14 cases (93%). In the patient whose aneurysm was not thrombosed by ultrasound compression, and in another patient with a very large pseudoaneurysm, angiography and open surgical treatment were essential. Finally, 2 patients had their aneurysms automatically (without compression) thrombosed during observation and no further treatment was given (Table 5).

Surgical techniques used to manage vascular complications on an emergency basis included suture of the bleeding vessel or bypass grafting. Interestingly, out of 15 hemorrhages or hematomas only 3 were managed surgically (Table 6).

Four patients were diagnosed with ipsilateral leg ischemia and lower extremity neurological signs: two with thrombosis of the common femoral artery and another two with peripheral embolisms. These patients were treated on an emergency basis with open endarterectomy and angioplasty, while the latter two patients underwent open femoral artery embolectomy and primary arterial closure (Table 7).

A total of 10 (22.2%) minor secondary complications were identified after the initial management of the vascular iatrogenic injury. These secondary complications were evaluated and recorded during the 30 days of follow up of all patients who were managed either conservatively or surgically. There were no deaths or amputations. Eight out of ten of these complications were treated conservatively, whereas an abscess and a seroma were successfully aspirated transcutaneously. These secondary complications resolved completely and did not increase the length of hospital stay (Table 8). The total length of hospital stay was 3.4 (range 1-8) days for the early detected complications and 5.1 (range 2-11) days for the late complications.

Table 2. Summary of management for early detected vascular complications.

Patient	Age/sex	Therapeutic/ diagnostic	Complications (symptoms/signs)	Days to present	Diagnostic test	Diagnosis	Management
1	72 m	Therapeutic	PGM	4	US/DSA	PSA	Surgical repair (elective)
2	68 f	Therapeutic	Leg extremity ischemia	1	None	Arterial embolism	Surgical repair (emergency)
3	48 m	Diagnostic	PGM	2	US	PSA	Conservative
4	47 m	Therapeutic	PGM	4	US	PSA	Conservative
5	56 f	Therapeutic	PGM	7	US	PSA	Conservative
6	65 m	Diagnostic	Hematoma	2	None	Hematoma	Conservative
7	70 f	Therapeutic	Hematoma	2	None	Hematoma	Conservative
8	78 f	Diagnostic	PGM	2	US	PSA	Conservative
9	54 m	Diagnostic	Hemorrhage	1	None	Bleeding	Surgical repair (emergency)
10	62 f	Diagnostic	Leg extremity ischemia	1	DSA	Arterial embolism	Surgical repair (emergency)
11	48 m	Therapeutic	PGM	5	US	PSA	Conservative
12	75 m	Therapeutic	Leg extremity ischemia	1	US	Arterial thrombosis	Surgical repair (emergency)
13	69 f	Diagnostic	Hemorrhage	1	None	Bleeding	Conservative
14	71 f	Therapeutic	PGM	6	US	PSA	Conservative
15	80 m	Therapeutic	Hematoma	1	CT	Hematoma	Conservative
16	65 m	Therapeutic	PGM	3	US	PSA	Conservative
17	84 f	Diagnostic	PGM	2	US	PSA	Conservative
18	59 m	Diagnostic	Leg extremity ischemia	1	US	Arterial thrombosis	Surgical repair (emergency)
19	60 m	Therapeutic	Hemorrhage	2	None	Bleeding	Surgical repair (emergency)
20	73 m	Diagnostic	PGM	2	US	PSA	Conservative
21	68 f	Therapeutic	Hemorrhage	1	None	Bleeding	Conservative
22	67 f	Therapeutic	Hematoma	2	CT	Hematoma	Conservative
23	52 m	Therapeutic	PGM	7	US	PSA	Conservative
24	58 m	Diagnostic	PGM	2	US	PSA	Conservative
25	61 f	Diagnostic	Hematoma	2	US	Hematoma	Conservative
26	67 m	Therapeutic	Hemorrhage	1	None	Bleeding	Surgical repair (emergency)
27	71 m	Therapeutic	Hematoma	2	US	Hematoma	Conservative
28	59 f	Diagnostic	Hematoma	2	US	Hematoma	Conservative
29	60 f	Diagnostic	Hemorrhage	1	None	Bleeding	Surgical repair (emergency)
30	72 m	Therapeutic	Hematoma	2	US	Hematoma	Conservative

CT – computed tomography; DSA – digital subtraction angiography; None – only clinical evaluation; PGM – pulsatile groin mass; PSA – pseudoaneurysm; US – vascular ultrasound.

Table 3. Summary of management for late detected vascular complications.

Patient	Age/sex diagnostic	Therapeutic/ (symptoms/signs)	Complications	Days to present	Diagnostic test	Diagnosis	Management
1	70m	Diagnostic	Murmur	60	None	AV fistula	Conservative
2	67m	Diagnostic	PGM	42	US	PSA	Conservative
3	47f	Therapeutic	Edema	14	US	DVT	Conservative
4	55m	Therapeutic	Edema	10	US	DVT	Conservative
5	52m	Therapeutic	PGM	14	US	PSA	Conservative
6	70f	Diagnostic	PGM	30	US	PSA	Conservative
7	49m	Therapeutic	Murmur	13	None	AV fistula	Surgical repair (elective)
8	48m	Therapeutic	Edema	15	US	DVT	Conservative
9	71f	Diagnostic	Edema	13	US	DVT	Conservative
10	65m	Therapeutic	PGM	15	US/DSA	PSA	Surgical repair (elective)
11	62m	Diagnostic	Hematoma	5	US	Bleeding	Conservative
12	59m	Diagnostic	Edema	12	US	DVT	Conservative
13	58m	Therapeutic	PGM	22	US	PSA	Conservative
14	60f	Diagnostic	PGM	48	US	PSA	Conservative
15	65m	Therapeutic	Murmur	35	None	AV fistula	Conservative

AV fistula – arteriovenous fistula; CT – computed tomography; DSA – digital subtraction angiography; DVT – deep venous thrombosis; None – only clinical evaluation; PGM – pulsatile groin mass; PSA – pseudoaneurysm; US – vascular ultrasound.

Table 4. Summary of surgical or conservative management for all cases.

Signs/ symptoms		Diagnostic imaging		Diagnosis		Management	
Lower leg ischemia	4	US	28	Pseudoaneurysm	18	Conservative	34 (75.5%)
Hemorrhage	6	CT	2	Arterial embolism	2		
Hematoma	9	DSA	3	Arterial bleeding	6	Emergency surgical repair	8 (17.7%)
Edema	5	None	12	Arterial thrombosis	2	Elective surgical repair	3 (6.8%)
Murmur	3			Hematoma	9		
Pulsatile groin mass	18			Deep venous thrombosis	5	Total surgical repair	11 (24.5%)
				Arteriovenous fistula	3		

CT – computed tomography; DSA – digital subtraction angiography; US – vascular ultrasound.

Emergency surgical repair	18%	Elective surgical repair	7%	Conservative management	75%
Acute limb ischemia	4	Arteriovenous fistula	1	Hematoma	8
		Pseudoaneurysm	2	Hemorrhage	3
Arterial embolism	2			Deep venous thrombosis	5
Arterial thrombosis	2			Pseudoaneurysm	16
				Arteriovenous fistula	2
Hemorrhage	3				
Hematoma	1				

Table 5. Management of pseudoaneurysms.

Patient	Size (cm)	USC	USC Successful	Further diagnostic imaging	Management/outcome
1	7.4	No	–	DSA	ESR
3	2.4	Yes	Yes	None	ST
4	NR	Yes	Yes	None	ST
5	NR	No	–	None	ST
8	4.6	Yes	Yes	None	ST
11	5.0	Yes	Yes	None	ST
14	3.0	No	–	None	ST
16	4.0	Yes	Yes	None	ST
17	2.0	Yes	Yes	None	ST
20	3.9	Yes	Yes	None	ST
23	5.1	Yes	Yes	None	ST
24	4.0	Yes	Yes	None	ST
2*	3.5	Yes	Yes	None	ST
5*	NR	Yes	Yes	None	ST
6*	3.7	Yes	Yes	None	ST
10*	NR	Yes	No	DSA	ESR
13*	NR	Yes	Yes	None	ST
15*	6.2	Yes	Yes	None	ST

DSA – digital subtraction angiography; ESR – elective surgical repair; None – only clinical evaluation; NR – Not recorded; ST – successful thrombosis; USC – ultrasound compression. *patients with late complications

Discussion

Large studies have estimated the incidence of clinically significant arterial complications after cardiac catheterization to be between 0.3% and 1.0%.[11-13] In our study this incidence was 0.43%, allowing that under a prospective evaluation of complications this number could be higher. Among all complications, the rate of surgically treated complications is from 30% to 50% of the total,[5,9,13,14] whereas in our study only 25% of the complications were treated surgically, on either an emergency (18%) or an elective (7%) basis. Kresowik et al,[15]

Table 6. Management of bleeding, extending hematoma, hematocrit drop.

Patient	Diagnosis	Further diagnostic imaging	Treatment	Type of surgical treatment	Complication
6	Hematoma	None	Conservative		
7	Hematoma	None	Conservative		
9	Bleeding	None	Emergency surgical repair	Bypass grafting	
13	Bleeding	None	Conservative		Severe hypotension
15	Hematoma	CT	Conservative		Abscess
19	Bleeding	None	Emergency surgical repair	Suture of the bleeding vessel	
21	Bleeding	None	Conservative		Severe hypotension
22	Hematoma	CT	Conservative		
25	Hematoma	US	Conservative		
26	Bleeding	None	Emergency surgical repair	Bypass grafting	Seroma
27	Hematoma	US	Conservative		
28	Hematoma	US	Conservative		Severe hypotension
29	Bleeding	None	Emergency surgical repair	Suture of the bleeding vessel	
30	Hematoma	US	Conservative		Severe hypotension
11*	Hematoma	US	Conservative		

CT – computed tomography; None – only clinical evaluation; US – vascular ultrasound. *patient with late complications.

Table 7. Management of leg ischemia.

Patient	Further diagnostic imaging	Surgical treatment	Complication
2	None	Embolectomy Primary closure	
10	DSA	Embolectomy Primary closure	Limb edema
12	US	Endarterectomy Angioplasty	
18	US	Endarterectomy Angioplasty	

DSA – Digital subtraction angiography; US – vascular ultrasound.

Table 8. Management of secondary complications.

Complication	Conservative treatment	Surgical treatment	Total
Severe hypotension	4	0	4
Seroma	0	1	1
Wound infection	0	2	2
Limb edema	1	0	1
Abscess	0	1	1
Deep vein thrombosis	1	0	1
Total	6	4	10 (22.2 %)

in a prospective study, evaluated 144 patients with ultrasound examination after therapeutic cardiac catheterization performed with large sized sheaths and reported an incidence of clinically significant arterial complications of 9%. Similar results were obtained by Messina et al,[16] who reported a relation between sheath size and the incidence and significance of complications. However, nowadays sheath sizes are smaller, without any great variability in size. In our study the sheath size ranged between 6 and 8 F, and as a result we could not demonstrate any relation between sheath size and the probability of complications. Though arterial complications had been considered a surgical entity, conservative treatment for arterial complications was proposed years ago to be feasible in many cases.[17] The same conclusion could also be drawn from our study.

Pseudoaneurysms were the most frequent complication in this series. Clinical diagnosis of a pseudoaneurysm in the case of a femoral pulsatile mass is obvious. Duplex ultrasound is the method of choice to evaluate its size, the thrombotic material inside and the communication with the artery. In our study, manual compression of the aneurysm under ultrasound guidance was effective in all cases but one of complete aneurysm thrombosis. Spontaneous aneurysm thrombosis occurred in two of our cases and this scenario has also been described by others.[18,19] However, nowadays there is increased interest in the use of thrombin injection into the aneurysmal cavity to initiate thrombosis without compression. We tried this method once successfully and we aim to use it in the future as a first line pseudoaneurysm treatment.

Bleeding complications in our series constituted 33% of the total. In four cases urgent surgical repair was essential. Imaging in these situations was consid-

ered time consuming and was avoided, as has also been proposed by others.[20] In cases of large hematomas with possible retroperitoneal extension a proximal external iliac artery dissection and control was used, whereas in cases with obvious bleeding below the inguinal ligament we performed only a common femoral artery control. Primary arterial closure is the standard of care, but we twice performed a short bypass grafting because the arterial defect was too large in a relatively narrow artery. Our experience is that by applying wide-range conservative management the majority of cases can be successfully treated without surgery. This management must include restoration of the patient's hemostatic function, lowering blood pressure, possible transfusions and absolute bed rest. Of course, frequent hemoglobin measurements and close clinical assessment are essential so that the plan may be changed promptly to surgical treatment if necessary.

We diagnosed 5 cases of ipsilateral common femoral vein thrombosis. It is interesting that all patients were on clopidogrel and aspirin (3 cases) or aspirin alone. Post catheterization manual compression was the obvious cause for these thromboses and certainly antithrombotic medication does not offer prevention against deep vein thrombosis. Fortunately, all patients had complete or partial thrombus lysis with low molecular weight heparins. The incidence of deep vein thrombosis in our series was 0.05%. However, the incidence of an asymptomatic vein thrombosis is unknown and must be determined by a prospective study. We had one case of sudden death 3 days after cardiac diagnostic catheterization, due to documented pulmonary embolism without evidence of femoral vein thrombosis (for this reason the patient was not included in this study).

Leg ischemia was in all cases treated surgically. Two different types of acute ischemia were evaluated: a case of atheromatous plaque disruption and peripheral embolism, and a case of femoral artery thrombosis at the point of catheterization as a result of arterial dissection or atheromatous plaque thrombosis. Fortunately, we had no limb loss in our patients, although amputation is a rare but real danger when dealing with advanced limb ischemia.[21]

The mechanisms of complications after catheterization are dependent on proper catheterization technique, on vessel pathology (atherosclerotic plaque at the site of catheterization), on the method and duration of manual compression applied, on concomitant antithrombotic medication and hypertension control. The lack of consistency in the presence and significance of these factors was clear reason in our study, as in others, for not performing comparisons. Matching groups of patients presenting these complications is infeasible in a retrospective analysis and, as a consequence, we were unable to draw conclusions as regards the significance of these factors for the occurrence of arterial complications. However, the our results showed that: 1) close clinical observation and early estimation of the severity of the complication can limit surgical treatment to 25% of all cases; and 2) a significant number of complications (33% of the total) present weeks or months after the catheterization. These late complications, which have been underestimated, do carry a considerable morbidity (deep vein thrombosis, pseudoaneurysms and arteriovenous fistulas) and also need treatment.

Limitations of the study

The main limitation of the present study is its retrospective nature. Certainly, some of the patients who underwent a cardiac catheterization and presented a late vascular complication may have been admitted to another hospital for treatment. Additionally, some patients may have presented some type of complication that was not easily detectable (small pseudoaneurysm) or asymptomatic (arteriovenous fistula). The case of a patient with intermittent claudication some weeks after catheterization was a typical diagnostic problem in our series. It could be a complication of the catheterization or simply a worsening of a peripheral artery atherosclerosis unmasked during walking exercise. We faced this situation twice, but intra-arterial angiography (which is one way to answer the question) was not deemed to be clinically indicated, carrying higher risk than the anticipated diagnostic benefit.

Finally, our study, like the majority of those published in this area, involved a group of cardiac patients who were receiving one or more different antithrombotic regimens. Obviously, an arterial bleeding following thrombolytic therapy combined with heparin in a patient who is also taking glycoprotein IIa/ IIIb platelet inhibitors carries a different prognosis than a similar event in a patient under acetylic acid treatment only. This variation amounts to a very important factor that makes it almost impossible for retrospective studies to form the basis for specific decision-making algorithms for these patients. However, our study answers some critical points of management and shows the importance of favoring conservative measures alone, as the

initial step, which are effective in up to 75% of the cases. Certainly, the management of femoral arterial complications, though a well described clinical problem for many years, will continue to be individualized but will also attract new studies.[22]

Conclusions

Complications of cardiac catheterization are uncommon, but when unrecognized or untreated they may have sequelae that are limb- or life-threatening. Early clinical identification and vascular surgery consultation are of the greatest importance. Proper estimation of the need for urgent surgical treatment is mandatory for severe retroperitoneal bleeding or advanced leg ischemia. Imaging in these setting may be time consuming and therefore is rarely performed. Complications that are not urgently threatening, such as pseudoaneurysms, stable arterial hematomas and arteriovenous fistulas, can be initially managed conservatively with ultrasound imaging and compression when needed, and are only treated surgically in cases which do not respond. Deep vein thrombosis is a underestimated complication in this group of patients. Although cardiac patients are usually under antithrombotic medication, this does not prevent deep vein thrombosis; in the case of a post-compression venous thrombosis a low molecular weight heparin is absolutely indicated. Finally, uneventful hospital discharge after a cardiac catheterization does not exclude the possibility of a late onset arterial complication. These are usually pseudoaneurysms or arteriovenous fistulas, occur at a rate of 30% compared to acute onset complications, and also require evaluation and treatment.

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