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Nonsurgical Closure of Femoral Pseudoaneurysms Complicating Cardiac Catheterization and Percutaneous Transluminal Coronary Angioplasty

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Objectives. This study was performed to describe the initial experience and follow-up of ultrasound-guided compression of pseudoaneurysms in patients receiving systemic anticoagulant or antiplatelet therapy, or both, after recent cardiac catheterization or percutaneous transluminal coronary angioplasty.

Background. Femoral artery pseudoaneurysm formation after an interventional procedure is becoming more common as larger caliber catheters and prolonged anticoagulant and antiplatelet therapy are being used. Traditional treatment of this complication has been surgical repair. This study describes a new method of closing femoral pseudoaneurysms by using external compression guided by Doppler color flow imaging.

Methods. Fifteen patients, 3 undergoing cardiac catheterization and 12 undergoing coronary angioplasty, developed an expansile groin mass at the vascular access site diagnosed as a femoral artery pseudoaneurysm by Doppler ultrasound. Seven of the patients had undergone coronary stenting and were receiving postprocedural anticoagulant therapy. These patients underwent progressive graded mechanical (C-clamp) external compression guided by ultrasound. The mechanical compression was titrated to obliterate the vascular tracts to these aneurysms and maintain adequate flow in the femoral artery.

Results. After an average compression time of 30 min (range 10 to 120), these tracts remained closed. Follow-up ultrasound examination at 24 h or later confirmed continued closure in all.

Conclusions. This study suggests that nonsurgical closure of femoral pseudoaneurysms is feasible. This technique may be valuable in managing vascular access-related complications after diagnostic and interventional procedures, even in patients requiring prolonged anticoagulant therapy.

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The incidence of vascular complications involving the peripheral access site is increasing with greater use of larger-sized arterial cannulas and peri- and postprocedural use of antithrombotic or thrombolytic agents, or both (1–4). The incidence of both femoral arteriovenous fistula and pseudoaneurysm has ranged from as low as 0.02% to as high as 9% in current studies (5–13).

The clinical diagnosis of femoral pseudoaneurysm can be made readily in the presence of a pulsatile mass, localized tenderness and an arterial bruit at the vascular access site. Noninvasive techniques utilizing duplex sonography and Doppler color flow imaging have been useful in confirming the clinical diagnosis and delineating the location and size of the pseudoaneurysm and presence of arteriovenous fistula (14–18). Although small pseudoaneurysms often close spontaneously without sequelae, they may enlarge and hemorrhage, especially in patients who require prolonged therapy with anticoagulant and antiplatelet agents (13).

Once the diagnosis of a femoral artery pseudoaneurysm is established, standard treatment consists of open surgical repair of the arterial defect and evacuation of the hematoma (19). Postoperative care in this cohort of patients may be difficult because many require uninterrupted anticoagulant therapy after undergoing newer coronary angioplasty techniques, such as intracoronary stenting. In these patients continuation of anticoagulant therapy may result in severe local bleeding. Alternatively, discontinuation of anticoagulant therapy may lead to acute closure of the angioplasty or stented site (20).

The successful closure of pseudoaneurysms and arteriovenous fistulas in patients undergoing diagnostic cardiac catheterization has been previously described (21). This study presents our initial experience with ultrasound-guided compression of a pseudoaneurysm in patients receiving systemic anticoagulant or antiplatelet therapy, or both, after recent cardiac catheterization or coronary angioplasty.

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Table 1. Clinical and Doppler Color Flow Characteristics and Follow-Up of Pseudoaneurysm Treated by External Compression

	Age (yr)/ Gender	DFP	Proc	PT (s)	PTT (s)	PSA Size (cm)		TCW (cm)	TCL (cm)	EC Result	Doppler F/U	
						D1	D2				Time	Result
1	74/M	12	A+S	*	45	4.0	2.3	0.30	†	Closure	9 days	No PSA
2	84/F	2	A	*	‡	2.5	1.5	0.32	2.30	Closure	3 days	No PSA
3	55/M	7	A+S	*	50	3.2	2.3	0.25	0.70	Closure	2 days	No PSA
4	55/M	12	A+S	*	50	5.4	4.0	0.30	1.20	Closure	2 days	No PSA
5	59/F	5	A+S	29	‡	1.9	1.5	0.20	1.83	Closure	29 days	No PSA
6	59/F	4	A	20	‡	§	§	0.30	2.40	Closure	23 days	No PSA
7	66/M	4	A+S	19.3	‡	2.8	1.5	0.22	1.40	Closure	3 days	No PSA
8	61/F	2	C	*	40	7.5	1.8	0.30	1.74	Closure	7 days	No PSA
9	43/F	2	C	*	‡	1.7	0.8	0.22	1.36	Closure	1 day	No PSA
10	65/F	1	C	*	‡	3.6	1.5	0.37	2.40	Closure	1 day	No PSA
11	64/M	3	A	*	49	1.2	0.6	0.20	0.34	Closure	3 days	No PSA
12	71/F	5	A+S	19.3	‡	1.1	0.5	0.17	0.38	Closure	No F/U	No F/U
13	45/M	5	A+S	16.7	‡	4.8	1.4	0.26	0.84	Closure	55 days	No PSA
14	56/F	3	A	*	‡	6.8	1.2	0.3[illegible]	[illegible]	Closure	1 day	No PSA
15	80/M	8	A	19.1	‡	1.1	0.7	0.26	0.97	Closure	5 days	No PSA
16	79/M	1	A	*	50	3.0	2.0	0.31	0.84	Closure	2 days	No PSA
17	53/M	3	A+S	16.3	70	10.0	2.0	0.26	†	Closure	1 day	No PSA

*Patient was receiving subtherapeutic or no coumadin. †No tract present. ‡Patient was receiving subtherapeutic or no heparin. §Patent tract with no cavity formation. A = angioplasty; C = cardiac catheterization; D1 = superoinferior diameter; D2 = anteroposterior diameter; DFP = days from the arterial puncture; EC = external compression; F = female; F/U = follow-up; M = male; Proc = invasive procedure; PSA = pseudoaneurysm; PT = prothrombin time on the day of external compression (control = 12); PTT = partial thromboplastine time within 8 h of the external compression (control = 30); S = coronary artery stenting; TCL = communicating tract length; TCW = communicating tract width.

Methods

Study patients. The study group consisted of 15 patients with Doppler color flow evidence of femoral artery pseudoaneurysm who underwent external compression at this institution from May through December 1991. These patients represent a subset of patients who were diagnosed as having pseudoaneurysm after clinical screening of 1,189 patients undergoing cardiac catheterization and 960 undergoing coronary angioplasty during this 8-month period. Patients with a pulsatile mass or large hematoma over the femoral puncture site were referred for Doppler ultrasound studies. Eighty-seven of these patients were routinely screened with ultrasound studies before discharge as part of a prospective evaluation of the use of this technology. The presence of a pseudoaneurysm was defined by ultrasound as the presence of a hypoechogenic cavity that communicated with the arterial lumen by a sinus tract directly visible by Doppler color flow imaging and pulsed ultrasound evidence of to and fro motion of blood flow between the cavity and the arterial lumen. Three of the 15 patients in this study had undergone cardiac catheterization and 12 had undergone coronary angioplasty. Informed consent for cardiac interventions and treatment of complications was obtained from each patient under a protocol approved by the Institutional Review Board.

Results

Patient characteristics are shown in Table 1. Two patients developed an expansile pseudoaneurysm in both instrumented groins; therefore, 17 pseudoaneurysms were present. The mean time from cardiac catheterization or coronary angioplasty to compression closure was 5 days (range 2 to 12).

Cardiac catheterization and coronary angioplasty. The left or right groin was prepared in the standard fashion with use of a sterile technique. Local anesthesia was obtained by infiltrating 1% carbocaine into the superficial and deep tissues surrounding the femoral artery. Arterial puncture was performed with the Seldinger technique. Cardiac catheterization and coronary angioplasty were performed with previously described techniques. After catheterization the vascular sheath was removed, on average, 4 h later. Hemostasis was achieved in all patients.

Medications. Of the 15 patients, 7 were taking aspirin 325 mg twice a day, dipyridamole 75 mg three times a day and intravenous heparin adjusted to keep the partial thromboplastin time between 55 to 75 s (2 to 2.5 times control). In three patients intravenous heparin was stopped 6 h before compression and later resumed. In one patient heparin was discontinued 48 h before the compression procedure. One patient had a prothrombin time of 26 s (>2 times control). At the time of compression, all patients received small, incremental, intravenous doses of diazepam (total dose of 5 to 20 mg) and morphine (total dose of 8 to 32 mg) to assuage local discomfort during the procedure.

Technique of external compression. All patients were placed in the supine position. A C-clamp (Clamp Ease, Pressure Product) was used for external compression. The base of the C-clamp was placed under the hip of the treated

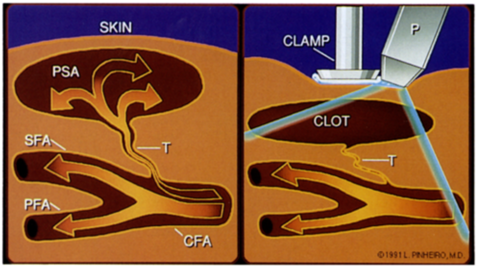

Figure 1. Noninvasive technique for closure of a femoral artery pseudoaneurysm (PSA) by external compression. **Arrows** represent the course and direction of blood flow. **Left panel,** Blood is shown flowing from the common femoral artery (CFA) into a large pseudoaneurysm (PSA) through a large tract (T). **Right panel,** External application of pressure using a vascular clamp guided by Doppler ultrasound color flow probe (P), results in obliteration of the tract and clot formation in the pseudoaneurysm. PFA = profunda femoris artery; SFA = superficial femoral artery.

side. All treated sites underwent baseline diagnostic study with use of an Acuson 128 ultrasound machine (Acuson), employing several views in the long and short axis with use of 7.5-MHz linear array and 5.0- to 7.5-MHz dual-frequency phased array probes. The tract connecting the femoral artery and the overlying pseudoaneurysm was localized with use of duplex ultrasound and Doppler color flow imaging. The corresponding cutaneous site was identified in relation to the tract. The compression head of the clamp was covered with folded sterile 4 × 4-in. cotton gauze and placed on the skin overlying the vascular tract, as determined by ultrasound examination (Fig. 1). The ultrasound probe was placed just below the clamp head at about 45° so that the pseudoaneurysm cavity or tract, or both, could be visualized while compression was adjusted. Graded pressure was applied by slowly turning the C-clamp pressure knob until absence of color flow signals demonstrated total occlusion of the tract between the arterial lumen and pseudoaneurysm. Adequate flow in the distal femoral artery was maintained as demonstrated by Doppler color flow imaging. The initial compression time was titrated to patient tolerance and ranged from 10 to 40 min. After initial compression, the pressure was gradually reduced by releasing the pressure knob while scanning for flow in the femoral artery and in the pseudoaneurysm. If any evidence of flow within the pseudoaneurysm cavity was detected, pressure was reapplied for another 20 to 45 min as tolerated. When evidence of blood flow into the tract and in the pseudoaneurysm cavity was persistently absent for at least 5 min after removal of the clamp, a standard pressure bandage was applied for 12 h.

Vital signs were monitored at least every 15 min during compression in all patients. The systemic systolic pressure was maintained <140 mm Hg. In three patients intravenous nitroglycerin was given to control blood pressure. All patients were maintained at bed rest for a minimum of 12 h after the procedure and were permitted to ambulate thereafter. Repeat ultrasound examinations were performed within 24 to 36 h after compression or at discharge, or both. In

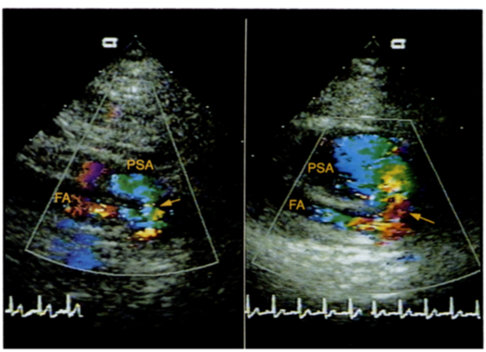

Figure 2. Patient 1. Doppler color flow ultrasonogram in the nonsurgical closure of a femoral artery pseudoaneurysm after coronary angioplasty. The femoral artery (FA) and pseudoaneurysm (PSA) are shown in the long-axis view. **Left,** A small residual pseudoaneurysm cavity (PSA) and the tract (**arrow**) after the first external compression are shown. **Right,** Repeat postcompression imaging of the femoral artery 24 h after ambulation demonstrating a marked increase in the size of the pseudoaneurysm.

patients undergoing stent angioplasty (n = 7), intravenous heparin was restarted at least 6 h after closure and continued at a dose sufficient to maintain a partial thromboplastin time of 2 to 2.5 times control (60 to 75 s) until the patient developed a therapeutic prothrombin time (1.3 to 1.5 times control) on a stable dose of warfarin. The initial 14 patients were contacted 1 month after hospital discharge. The last patient was contacted 1 week after discharge. The patients were questioned about local groin pain or swelling, abnormal leg sensation, difficulty in walking and the need for physician contact or a hospital visit. If the patient was readmitted to this hospital, then repeat physical and ultrasound examinations of the groin were performed.

Immediate results. All patients tolerated mechanical compression without any clinical complications during or after the procedure. The tract was correctly identified and successfully closed by compression in all patients treated (95% confidence interval 80% to 100%). The mean duration of compression was 30 min (range 10 to 120). In one patient on anticoagulant therapy, the pseudoaneurysm did not have an identifiable tract (sessile cavity). This pseudoaneurysm was not closed completely by the first external compression, although the size of the cavity was reduced. The cavity size increased significantly within 24 h after ambulation (Fig. 2). In this patient warfarin therapy was discontinued and administration of heparin restarted. After normalization of prothrombin time, the patient underwent repeat external compression, and the cavity was effectively closed in response to a prolonged compression time of 120 min.

In-hospital follow-up. In 14 patients (16 pseudoaneurysms), follow-up Doppler ultrasound and color flow imaging showed no communication between the hematoma and the femoral artery (Table 1). In the 15th patient the treated groin remained clinically normal after ambulation, and she was discharged from the hospital before follow-up ultrasound examination could be performed. There were no other in-hospital complications related to the femoral artery puncture site in any patient.

Three patients had an invasive coronary procedure performed through the femoral artery subsequent to successful closure of a pseudoaneurysm in this vessel by external compression. A 64-year old man (Table 1, Patient 11) underwent coronary angioplasty 3 days after pseudoaneurysm closure during the same hospital stay. He had no recurrence of the pseudoaneurysm or other vascular sequelae. Another two patients had a second hospital stay for a cardiac procedure.

Follow-up after discharge. Telephone follow-up of discharged patients revealed freedom from significant groin discomfort, paresthesia or lower limb claudication in all but one. This patient (Patient 14) was admitted 3 days after discharge with continuing discomfort at the femoral puncture site. Repeat ultrasound examination revealed hematoma formation but no recurrence of the pseudoaneurysm. A blood transfusion was administered and the femoral site was managed with bed rest. A second patient, a 59-year old woman (Patient 5), was readmitted for chest pain 29 days after the compression procedure, and results of repeat ultrasound examination of the groin were normal. Subsequent repeat catheterization was carried out through the same artery without complication. A third patient was readmitted for unstable angina 55 days after external compression. Physical and ultrasound examination of the treated groin revealed normal findings, and he underwent repeat coronary angioplasty and coronary stenting using the same access site without any difficulty.

Discussion

Previous studies. Earlier studies (13,22) demonstrated that small pseudoaneurysms may close spontaneously within 4 to 8 weeks. None of the patients in these studies were receiving anticoagulant therapy and use of antiplatelet therapy was not described. The natural history of patients with a pseudoaneurysm maintained on these medications is unknown. However, in the recent past two such patients at our institution have required emergency repair of the artery because of enlargement of the pseudoaneurysm after discharge.

Although nonsurgical closure of a pseudoaneurysm has been achieved by direct intracavitary injection of thrombin (23), as well as transcatheter embolization (24), both of these techniques involve risks similar to those of direct surgical repair. Open surgical repair of a femoral pseudoaneurysm in patients not on anticoagulant therapy has been shown to be safe and effective (12). However, the discontinuation of systemic anticoagulation soon after coronary angioplasty or stenting for the purpose of vascular surgical repair may result in abrupt coronary closure or stent thrombosis. Alternatively, massive groin hematoma can occur at the vascular repair site if anticoagulant therapy is reinstituted immediately after operation (20).

Current series. In this small series success was achieved in all patients without complicating coronary events or ischemic sequelae in the lower limbs despite discontinuation of anticoagulant therapy for a short (<12-h) period of time. A mechanical vascular clamp device was used to apply constant pressure to skin over the pseudoaneurysm tract while an ultrasound probe was employed to assess occlusion of the tract and adequate flow in the distal femoral artery. By ensuring distal flow in the femoral artery during compression, ischemic complications can be avoided. This difference in technique may explain our improved results in patients on anticoagulant therapy compared with those of Fellmeth et al. (21).

The mechanism of pseudoaneurysm closure by compression is consistent with the basic principles of thrombosis described by Virchow. Compression of the communicating tract appears to result in stasis in the pseudoaneurysm cavity that, if persistent, may induce therapeutic thrombosis (Fig. 1). Consistent with this idea, the current study patients on an

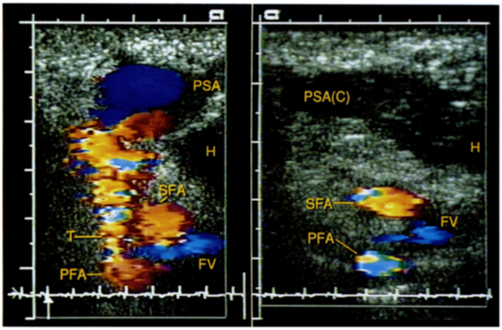

Figure 3. Patient 1. Doppler color flow ultrasonogram in the nonsurgical closure of a femoral artery pseudoaneurysm following percutaneous coronary angioplasty. The superficial (SFA) and profunda (PFA) femoral arteries are shown in cross section. The **left panel** depicts a long and large tract (T) connecting the profunda femoris artery (PFA) with the pseudoaneurysm (PSA) cavity. A hematoma (H) is present medial to the pseudoaneurysm cavity. The postcompression study (**right panel**) demonstrates complete obliteration of the connecting tract and absence of flow signals in the pseudoaneurysm cavity, indicating a closed pseudoaneurysm (PSA [C]), which now displays echogenicity identical to that of the previously visualized hematoma. FV = femoral vein.

aggressive anticoagulant regimen usually required compressions of longer duration.

If a pseudoaneurysm is surgically closed, the overlying cavity is commonly evacuated so that a large hematoma does not form. After external compression, the pseudoaneurysm cavity turns into a hematoma (Fig. 3 and 4). The hematoma may take a few days to weeks to resolve, depending on its size. This is illustrated by Patient 14 in whom a large hematoma was still present 1 week later. In contrast, two patients exhibited no physical or ultrasound evidence of hematoma or pseudoaneurysm 29 and 55 days, respectively, after external compression, and repeat catheterization was performed with use of the same artery without further sequelae.

In one patient on anticoagulant therapy with a large pseudoaneurysm, the cavity size reduced significantly, but the to and fro motion could not be suppressed. He began to ambulate and 24 h later had physical and ultrasound evidence of expansion of the pseudoaneurysm cavity. This observation suggests that complete abolition of the to and fro motion may be necessary to ensure success.

Conclusions. This initial experience with successful nonsurgical closure of pseudoaneurysms is encouraging, especially in the high risk group of patients who required contin-

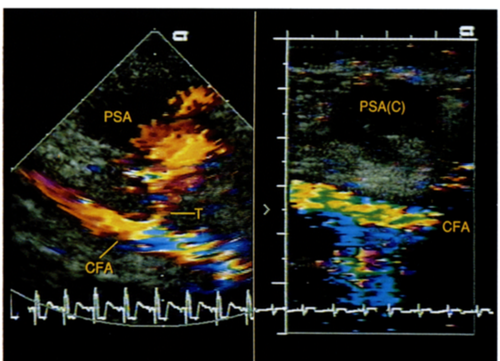

Figure 4. Patient 2. Doppler color flow ultrasound study of nonsurgical closure of a femoral artery pseudoaneurysm after coronary angioplasty and stenting. **Left panel,** Precompression study. The long-axis view systolic frame shows a tract (T) connecting the right common femoral artery (CFA) with the cavity of a large pseudoaneurysm (PSA). **Right panel,** Postcompression study. The tract is completely obliterated and no flow signals are apparent within the pseudoaneurysm, indicating pseudoaneurysm closure (PSA [C]).

uous anticoagulant therapy after percutaneous coronary revascularization. It is our opinion that even a small aneurysm in a patient on anticoagulant therapy should be closed before discharge. The method used in the current series employing Doppler color ultrasound guidance was associated with minimal risk and a high degree of success. Further experience with this new technique will help establish its safety and efficacy.

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