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Management of 219 Consecutive Cases of Postcatheterization Pseudoaneurysm

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Objectives. **We attempted to evaluate nonsurgical methods of treating postcatheterization pseudoaneurysm.**

Background. **The value of reapplication of a compression bandage, ultrasound-guided compression repair (UGCR) and awaiting spontaneous thrombosis in the treatment of postcatheterization pseudoaneurysms is unsettled.**

Methods. **We followed a stepwise treatment strategy of primarily conservative management using 1) reapplication of a compression bandage, followed by 2) UGCR, if needed, and 3) observation of the natural course. Surgical repair was reserved for patients with a rapidly expanding or complicated lesion.**

Results. **Reapplication of a compression bandage was performed in 128 patients and was successful in 32%. The success rate correlated inversely with anticoagulant therapy and the size of the aneurysm. In case of failure this pretreatment with a compression bandage significantly enhanced the success rate of subsequent UGCR ($p = 0.04$). UGCR was performed in 124 cases with a success rate of 84%. In 54 patients with a stable lesion, refraining from any (further) active measures resulted in spontaneous thrombosis of the aneurysm in 50 patients (93%) after 1 to 180 days (median 40 days). The course of the remaining four femoral artery aneurysms was uneventful. Definitive repair by operation or collagen plug implantation was required in only 20 patients (9%).**

Conclusions. **The first measure performed in the treatment of pseudoaneurysms should be reapplication of a compression bandage, followed, if necessary, by UGCR. After failure of UGCR, spontaneous healing occurs in the majority of patients. Operation can be reserved for progressive and complicated lesions.**

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Early surgical repair represents the traditional management of postcatheterization pseudoaneurysm and, despite the prolonged hospital stay and convalescent period of the patients (1–3), it is still favored by some investigators (4,5). The introduction of ultrasound-guided compression repair (UGCR) in 1991 (6) offered a promising nonoperative approach. Our experience (7) and that of others (8,9) with this technique confirmed its safety and efficacy, and UGCR rapidly gained wide acceptance. Nevertheless, up to 30% of lesions are not curable by this method, including cases in which UGCR is not feasible because of contraindications. Furthermore, the procedure is distressing for the patient and costly in terms of skilled manpower and sophisticated technical equipment. Therefore, alternative methods for the treatment of pseudoaneurysms would be of great interest.

Occasional reports involving small patient numbers (10–13) and our own experience indicated that simple reapplication of a compression bandage and waiting for spontaneous healing during a wait-and-see period may represent such alternative approaches. Therefore, with increasing experience we developed a treatment strategy based on stepwise escalation in the following order: renewed compression bandage, UGCR, waiting for spontaneous closure. Surgery or percutaneous implantation of collagen plugs (7,14–16) was reserved for rapidly progressive and actively bleeding lesions.

This report summarizes our results with such an approach in 219 consecutive cases of pseudoaneurysm. A detailed analysis of these data was carried out with the intention of defining prognostic criteria that would allow an individually optimized treatment plan for each patient.

Methods

Patients. Over a period of 4 years (January 1992 to December 1995), 18,315 femoral artery catheterizations were performed at our institution. During this period, all patients after coronary angioplasty (PTCA) (n = 1,556) and stent implantation (n = 1,530) routinely underwent color-coded duplex sonography (Acuson 128 with use of a 5-MHz linear array transducer) of the femoral artery. In addition, sonographic examination of the femoral artery was performed after any other catheter investigation in patients with hematoma, suspicious swelling or any other clinical abnormality of the puncture site. A pseudoaneurysm was identified as an extravascular cavity, exhibiting blood flow and communicating with the

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Abbreviations and Acronyms

PTCA = percutaneous transluminal coronary angioplasty
UGCR = ultrasound-guided compression repair

femoral artery through a connecting path showing the characteristic "to and fro" signal on pulsed Doppler analysis.

In 219 of the 18,315 patients, a pseudoaneurysm was discovered after PTCA and coronary stenting (n = 122), valvuloplasty (n = 2), coronary angiography (n = 73), peripheral angioplasty (n = 9) or angiography (n = 13) (Table 1).

In these patients, we compared baseline characteristics thought to be associated with a higher incidence of postcatheterization femoral artery injuries with the baseline characteristics of a control group of 400 consecutive patients who did not show a pseudoaneurysm after diagnostic or therapeutic cardiac catheterization.

Procedures. With growing experience in the nonsurgical management of pseudoaneurysm, we realized that reapplication of a compression bandage resulted in cure of the lesion in some patients. It also became clear that patients with uncomplicated lesions had a favorable clinical outcome when no active therapy was carried out. In most of these patients the pseudoaneurysm closed spontaneously, and the others had an uneventful course despite persistence of the lesion.

Therefore, in 1993 we developed a strategy based on a stepwise treatment plan in the following order: 1) reapplication of a compression bandage for 24 h; 2) performance of UGCR; and 3) observation of the natural course of the lesion. After each step, Doppler color flow examinations were performed. In case of treatment failure, the next step in the treatment plan was initiated. Only patients with large lesions ($\geq$6 cm^3) causing severe symptoms or lesions close to the surface of the skin (and therefore in danger of rupturing) underwent surgical repair of the pseudoaneurysm after failure of UGCR. Contraindications for application of a compression bandage and UGCR included skin ulceration or infection of the groin, intolerable groin tenderness or extremely poor general condition of the patient. In these patients, lesions were either merely observed (n = 18) or treated with primary surgery (n = 5). In patients receiving simultaneous intravenous and oral anticoagulant therapy, application of a compression bandage and UGCR were postponed until intravenous administration of heparin could be stopped.

During year 1 of the study, one or more steps of the protocol could be omitted by special request of the patient or the attending consultant; thus, in some patients treatment began with UGCR (n = 49), surgery (n = 3) or awaiting spontaneous healing (n = 14). Although our therapeutic approach changed slightly over the years, the patients were examined and the results were documented according to a uniform protocol beginning in January 1992. All patients were observed consecutively, and therapeutic measures were performed in a standardized fashion throughout the study period. Patients and procedures are summarized in Figure 1.

Reapplication of a compression bandage was carried out immediately after detection of a pseudoaneurysm. A small rectangular pad of sterile compresses was focused directly above the aneurysm track and fixed with a nonelastic bandage that was wrapped alternately around the hip and thigh of the patient. The compression bandage was considered to be firm enough, if slight manual extra pressure on the pad resulted in cessation of popliteal pulsations. Bed rest in a strictly supine position was maintained until removal of the bandage after 24 h.

UGCR was performed as previously described (7). In 79% of cases, the pressure required to eliminate extraluminal flow also occluded the underlying artery for the better part of the procedure. In contrast to other investigators (6,8,9), we did not consider this temporary arterial occlusion (maintained in some patients for up to 65 min with brief interruptions every 10 min to check whether the lesion was closed) a contraindication for UGCR. Although no local anesthesia was used, the majority of patients tolerated the procedure very well, and only a few required analgesic medication. One patient required short-term general anesthesia for UGCR. Five patients were treated with atropine for mild transitory vagal reactions. Irrespective of the immediate outcome of UGCR, all patients received a firm compression bandage and maintained strict bed rest for 24 h.

A "watch and wait" approach was deemed justifiable when lesions appeared to be clinically benign and were stable in size during at least two subsequent duplex scans. Before discharge, patients were instructed to avoid carrying heavy weight while the lesion persisted. Scheduled follow-up examinations were

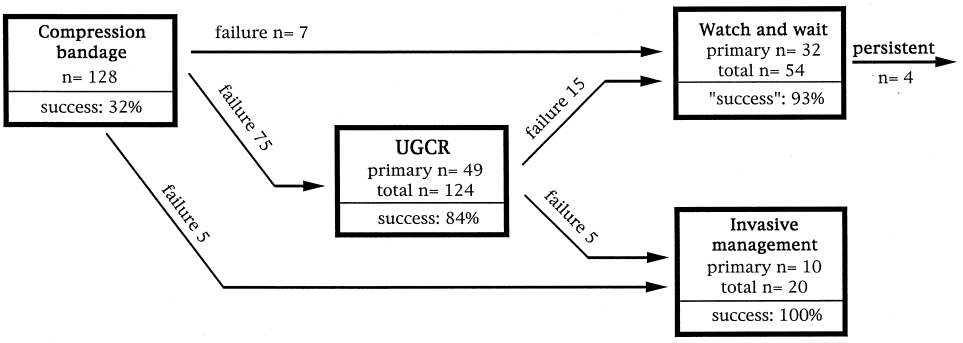

Figure 1. Flowchart of the modalities and outcome of the treatment of 219 false aneurysms. Invasive management refers to operation (n = 15) or percutaneous implantation of collagen plugs (n = 5).

performed after 4 weeks or after oral anticoagulant therapy was stopped, whichever occurred sooner. Thereafter, patients were seen as required by the clinical situation.

Percutaneous implantation of collagen plugs (Vasoseal, Datascope Inc.) into the extraluminal cavity (14–16) resulted in prompt closure of the pseudoaneurysm in five patients. Because of its limited feasibility, its higher risk of infection of the groin (16) and the high cost of collagen coils, this approach was soon abandoned.

Analysis of the data. For statistical analysis, the length of the aneurysm track and the size of the extraluminal cavity were estimated by color-coded duplex sonography in two orthogonally oriented scans. Aneurysm tracks ≥10 mm were defined as "long," those <10 mm as "short." The three-dimensional size of the lesion was estimated according to the simplified formula: Width × Length × Depth. For statistical analysis, pseudoaneurysms were subdivided into small lesions (<6 cm^3) and large lesions (≥6 cm^3) (10). The overall effect of single variables on the success rate was analyzed by using binary logistic regression (17), which was performed with stepwise forward selection of the variables. The following categoric variables were included: gender, Broca index (as defined by the formula: Body weight in kg/[Height in cm −100]), anticoagulant therapy, volume of the pseudoaneurysm, length of the aneurysm track and duration of the pseudoaneurysm (Table 2). Success rates within subgroups with various combinations of prognostic factors were compared by using the chi-square test (18). A p value < 0.05 in the two-tailed test was regarded as significant.

Results

Patients and factors predisposing to pseudoaneurysm. Of the 18,315 femoral artery catheterizations performed at our institution between January 1992 and December 1995, 7,569 were cardiac and 10,746 noncardiac procedures. A total of 219 patients were found to have a postcatheterization pseudoaneurysm. This group includes a series of patients with 53 previously reported pseudoaneurysms (7). Lesions were detected 1 to 56 days (median 3) after catheterization. In 22 of these patients, a pseudoaneurysm was found only after a second duplex scan was obtained because of sudden onset of pain or swelling of the groin despite a normal first duplex scan. The interval between catheterization and appearance of symptoms was 4 to 17 days (median 9) in these 22 patients. All 22 were receiving oral and intravenous anticoagulant agents after coronary stenting.

The baseline characteristics thought to be associated with a higher incidence of injuries after femoral artery catheterization (1,19–22) are summarized in Table 1. These factors were compared in the study group and in a control group of 400 consecutive patients who did not show a pseudoaneurysm after diagnostic or therapeutic cardiac catheterization (Table 1). There were no significant differences between the study and control groups with regard to age, gender, Broca index or frequency of systemic hypertension.

Table 1. Clinical Characteristics

	Patients with Pseudoaneurysm (n = 219)	Control Subjects (n = 400)	p Value
Men/women (no.)	146/73	288/112	0.60
Ratio	2.0:1	2.6:1	
Median age (yr)	66	63	0.72
Range	28–91	34–91	
Median Broca index*	1.08	1.07	0.86
Range	0.72–1.70	0.73–2.37	
Systemic hypertension† [no. (%) of patients]	99 (45.2%)	220 (55.0%)	0.21

*Defined by the formula Body weight (kg)/(Height [cm] − 100). †Defined as blood pressure ≥160/90 mm Hg.

Reapplication of a compression bandage. In 128 patients (58%) the pseudoaneurysm was treated initially by reapplication of a firm compression bandage for 24 h. This treatment was successful in 32%. Success rates within different subgroups are shown in Table 2. Neither gender, Broca index nor length of the aneurysm track was of prognostic significance for outcome of the compression bandage. However, there was a negative correlation between success rate and size of the lesion (≥6 cm^3) ($p = 0.006$) and anticoagulant therapy ($p = 0.01$). On combining these two prognostic factors, the highest success rate of the compression bandage was found in patients with a small aneurysm who were not receiving anticoagulant therapy (58%), but the treatment was <30% successful in patients with a large pseudoaneurysm who were receiving anticoagulant therapy. The compression bandage failed in 87 (68%) of the 128 patients, of whom 75 were subsequently treated by UGCR and 7 had spontaneous thrombosis. The other five patients underwent an invasive procedure: the implantation of collagen plugs in one patient and surgical treatment in four (Fig. 1).

UGCR. One hundred twenty-four patients were treated by UGCR, which was performed as the primary measure in 49 patients and as a secondary measure after failure of reapplication of a compression bandage in 75. UGCR was successful in 104 patients (84%). The success rate was significantly correlated with lack of anticoagulant therapy ($p = 0.0001$) and with length of the aneurysm track ($p = 0.0001$) (Table 2). In addition, success was significantly more likely after pretreatment with a compression bandage (89% vs. 76%, $p = 0.04$). The positive effect of pretreatment with a compression bandage was particularly evident in patients receiving anticoagulant agents (81% vs. 53%, $p = 0.03$) (Table 3). The median compression time to achieve occlusion was 30 min (range 10 to 65) and was not affected by pretreatment with a compression bandage nor by any of the variables listed in Table 2.

In seven patients the pseudoaneurysm recurred 1 to 7 days (median 1 day) after initially successful UGCR. Repeat UGCR was attempted in all seven and was successful in five. Those 2 failures and the 18 primary failures of UGCR yield a total of 20 UGCR failures. Of the 20 patients with UGCR failure, 15 showed spontaneous thrombosis, 3 underwent sur-

Table 2. Success Rates of Compression Bandage and Ultrasound-Guided Compression Repair in Various Subgroups

	Compression Bandage		UGCR	
	Success	p Value*	Success	p Value*
All	41/128 (32.0%)		104/124 (83.6%)	
Men	30/88 (34.0%)	0.29	69/82 (84.1%)	0.68
Women	11/40 (27.5%)		35/42 (83.3%)	
Broca index				
≤1.2	33/103 (32.0%)	0.58	82/96 (85.4%)	0.22
>1.2	8/25 (32.0%)		22/28 (78.5%)	
Anticoagulant therapy				
Yes	11/50 (22.0%)	0.01	38/53 (71.6%)	0.0001
No	30/78 (38.5%)		66/71 (92.9%)	
Volume (cm^3)				
<6	31/76 (40.8%)	0.006	43/56 (76.8%)	0.53
≥6	10/52 (19.2%)		61/68 (89.7%)	
Aneurysm track (mm)				
<10	20/66 (30.3%)	0.74	42/59 (71.1%)	0.0001
≥10	21/62 (33.8%)		62/65 (95.3%)	
Duration (days)				
≤5	41/127 (31.8%)	0.87	88/98 (89.7%)	0.11
6–20	0/1		14/23 (60.8%)	
>20	0/0		2/3 (66.6%)	

*Calculated by using binary logistic regression. †As defined by the formula Length × Width × Depth. Data presented are number (%) of patients. UGCR = ultrasound-guided compression repair.

gical repair; 1 patient with a persisting lesion died of renal failure and 1 patient was lost to follow-up.

Observation of the natural course. In 32 patients, the pseudoaneurysm was merely observed without any preceding active therapy. The observational approach was used particularly often in the initial phase of our experience, where 15 patients receiving anticoagulant agents and 3 with a very small and clinically benign lesion were merely observed. Five other patients were treated purely with observation because of contraindications to compression therapy (three in a very poor physical state and two with necrosis of the skin); the remaining nine patients had spontaneous closure of the lesion while waiting for compression therapy. In an additional 22 patients no further active therapy was carried out after failure of the compression bandage (n = 7) or UGCR (n = 15) (Fig. 1). Spontaneous thrombosis occurred in 50 (93%) of these 54 pseudoaneurysms. Two patients with a persisting lesion died (one of renal failure, one of cancer); two other patients were lost to sonographic follow-up but are still alive and well. Details of the 50 lesions with spontaneous thrombosis are listed in Table 4. Although in 20 patients spontaneous closure did not occur until oral (n = 17) or intravenous (n = 3) anticoagulant therapy was ended, thrombosis occurred in 15 patients while they were still receiving oral anticoagulant agents (phenprocoumon, international normalized ratio 3.0 to 4.5). Neither size of the pseudoaneurysm nor length of the aneurysm track was a predictor of spontaneous thrombosis in this group of patients (Table 4). However, spontaneous closure during anticoagulant therapy seemed to occur more often in

Table 3. Success Rate of Ultrasound-Guided Compression Repair in Patients With or Without Anticoagulant Therapy, Pretreatment With a Compression Bandage and Length of the Aneurysm Track

	Without Anticoagulant Therapy		With Anticoagulant Therapy	
Aneurysm Track	With Pretreatment	Without Pretreatment	With Pretreatment	Without Pretreatment
<10 mm	24/25 (96%)	10/13 (77%)	7/14 (50%)	1/7) (14%)
≥10 mm	14/14 (100%)	18/19 (95%)	22/22 (100%)	8/10 (80%)

Data presented are number (%) of patients.

Table 4. Characteristics of the 50 Lesions With Spontaneous Thrombosis

	After Cessation of Anticoagulant Therapy* (n = 20)	With Anticoagulant Therapy (n = 15)	Without Anticoagulant Therapy (n = 15)
Aneurysm track (mm)			
<10	14	6	9
≥10	6	9	6
Lesion size (cm^3)			
<6	13	10	7
≥6	7	5	8
Median days until closure	40	5	5
Range	1–180	1–48	1–23

*Phenprocoumon in 17 patients and intravenous heparin in 3.

lesions with a long aneurysm track. The interval from diagnosis of the lesion to confirmation of its closure ranged from 1 to 180 days (median 40 days).

Surgical repair. Surgical repair was performed in 15 patients (7%). Immediate surgical repair of a rapidly expanding (n = 4) or actively bleeding (n = 1) lesion was required in five cases. Another three lesions were repaired on the occasion of emergency cardiac surgery without a preceding attempt at noninvasive therapy. In the remaining seven patients surgical repair had to be performed after failure of compression bandage (n = 4) or UGCR (n = 5), or both, because of necrosis of the skin (n = 2) or expansion of a large lesion (n = 6), or both. The rate of surgical interventions decreased from 10% (9 of 93) between 1992 and 1993 to 5% (6 of 126) during the rest of the study period.

Discussion

Our study differs from other studies of noninvasive treatment of pseudoaneurysms (6,8,9) in two major aspects: 1) reapplication of a compression bandage before UGCR, and 2) withholding of active therapy in a selected, but sizable subgroup of patients.

Reapplication of a compression bandage. Treatment with a compression bandage was significantly less successful (32%) than UGCR (84%, $p < 0.0001$). This result may be attributed to the exactly focused manual application of a higher degree of pressure in the course of UGCR. Success of the compression bandage was inversely associated with the use of anticoagulant agents ($p = 0.001$) and size of the aneurysmal cavity ($p = 0.006$). Accordingly, the highest success rate was found in patients with normal hemostasis and a small lesion (58%). Despite its lower success rate, reapplication of a compression bandage offers several advantages over UGCR: 1) It causes less discomfort than UGCR; 2) it is less costly in terms of personnel and use of highly technical equipment; and 3) it enhances the success rate of subsequent UGCR. It remains speculative whether the positive effect of this method on the outcome of UGCR is caused by partial thrombosis of the aneurysmal cavity, enhancing its thrombogenicity, or simple attenuation of the surrounding hematoma, which might improve the conditions for subsequent sonographically controlled compression.

UGCR. Corroborating the results of a previously published study (7), UGCR was significantly more effective in patients who were not receiving anticoagulant therapy ($p = 0.0001$) and in lesions with a long aneurysm track ($p = 0.0001$). Size and duration of the lesions, which others (6,8,23) found to be inversely associated with success of UGCR, were of no prognostic value in our study. In contrast to current reports (6,8,9), we did not find temporary occlusion of the femoral artery to be prohibitive for UGCR; it occurred in 78% of our cases and caused no undue complications. Thus, the indication for sonographic compression can safely be extended to patients in whom such occlusion occurs.

Observation of the natural course. We observed spontaneous thrombosis in 50 (93%) of 54 lesions that were considered eligible for our watch and wait approach. Our results in these patients differ in several respects from assumptions made in smaller patient series. Kent et al. (10) and others (11,12,24) assumed that awaiting the natural course may not be feasible in patients with a large lesion (>6 cm^3) and in those who are receiving anticoagulant medication. Furthermore, they suggested that lesions persisting for >2 months should be repaired, because they are unlikely to undergo thrombosis. Our data contradict these suggestions as we found spontaneous healing in large pseudoaneurysms (n = 20), in lesions of patients receiving anticoagulant therapy (n = 15) and in lesions that had been observed for >2 months (n = 3).

Conclusions. The finding of a 93% success rate of a purely conservative approach might suggest that complete avoidance of active treatment might represent the wisest strategy for uncomplicated postcatheterization pseudoaneurysms. However, this course would unduly prolong the hospital stay, because the stability of the lesion would have to be ascertained over several days, before the patient could safely be discharged. In addition, it would impose prolonged restrictions on the physical activity of many patients and expose all of them to the fear of possible late rupture. Therefore, rather than primary abstinence from all active therapy, treatment by simple means, such as reapplication of a compression bandage or UGCR, should be the rule.

Details of our findings may be questioned because our study was not a randomized trial of use of a secondary compression bandage, UGCR and a watch and wait approach for the treatment of postcatheterization pseudoaneurysm, rather, it was an observational study with a treatment strategy that evolved and changed slightly over the years. However, our findings, which were obtained in a large number of consecutive, unselected patients who were followed up and documented prospectively in a uniform fashion, appear to provide sufficient support for the following conclusions: 1) A compression bandage should be the first step in a treatment protocol for pseudoaneurysms of the femoral artery, followed by UGCR if this initial treatment fails. 2) If UGCR fails, awaiting spontaneous healing is a safe, efficacious and cost-effective alternative to surgical repair of stable lesions. 3) Surgery can be reserved for progressive, actively bleeding or otherwise complicated lesions and may safely be withheld in a large majority of patients with an uncomplicated postcatheterization pseudoaneurysm.

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