New Aspects in Ultrasound-Guided Compression Repair of Postcatheterization Femoral Artery Injuries

F. Schaub, MD; W. Theiss, MD; M. Heinz, MD; M. Zagel, MD; A. Schömig, MD

Background This study was undertaken to expand the understanding of ultrasound-guided compression repair (UGCR) of postcatheterization femoral artery injuries.

Methods and Results In a series of 62 patients with pseudoaneurysms (n=53) or arteriovenous (AV) fistulas (n=9), UGCR was performed as a nonsurgical method in the treatment of postcatheterization femoral artery injuries. When the communicating channel could be visualized (43 cases), pressure was focused on it; otherwise (10 cases) the extraluminal cavity itself was compressed. In 45 cases, the elimination of flow in the pseudoaneurysm and/or the communicating channel could be achieved only with simultaneous temporary complete occlusion of the femoral artery. UGCR was successfully performed in 25 of 27 cases of false aneurysms (93%) in patients without anticoagulation and in 14 of 26 patients (54%) on anticoagulants. Three of 9 AV fistulas could be repaired by this method. No apparent correlation could be found between the therapeutic success and the size of the pseudoaneurysm or the age of the lesion.

Conclusions In patients on anticoagulants and in patients with AV fistulas, the detection of a communicating channel that could be obliterated by direct mechanical compression was discerned as a discriminant factor of success. (Circulation. 1994;90:1861-1865.)

Key Words • aneurysm • fistula • ultrasounds

In 1991 Fellmeth et al1-2 introduced ultrasound-guided compression repair (UGCR) of postcatheterization femoral artery injuries. They reported their experience in a total of 53 patients, defining the criteria for indications and performance of UGCR. This method has rapidly gained wide acceptance, and a number of positive case reports and small patient series have basically confirmed its value.3-10 The total number of patients reported, however, is still small, and correspondingly, uncertainties concerning patient selection and technical details still persist.

Since our methodology and our results differ in several aspects from the data published so far, we report our experiences in 62 patients whom we have treated with UGCR for false aneurysms and atioventricular (AV) fistulas.

Methods

Color-coded duplex sonography using a 5-MHz linear-array transducer (Acuson 128) was routinely performed in all patients after implantation of coronary stents. Patients after other cardiac catheterization procedures or after peripheral percutaneous transluminal angioplasty were examined if they complained of persistent pain in the groin or when groin hematoma or bruises at the puncture site were discovered during clinical examination. Pseudoaneurysms were identified according to the customary criteria of an extravascular cavity communicating with the arterial lumen by a channel, displaying the typical to and fro signal on Doppler examination.11,12

AV fistulas were identified by the presence of a continuous AV shunt with increased diastolic flow in the supplying artery and pronounced turbulence within the vein draining the fistula.

Patients with pseudoaneurysms and AV fistulas were considered candidates for UGCR if reapplication of a firm compression bandage for 24 hours failed to cure the lesion and if contraindications could be ruled out; the latter included infection, overlying skin ischemia, impending compartment syndrome, and severe pain in the groin.

The following procedure was used throughout the entire course of our study without any subsequent modifications: First, an attempt was made to detect the tract or neck leading from the arterial lumen to the lesion. The transducer was then positioned directly above the tract, and pressure was increased gradually until flow in the tract was eliminated. If the tract could not be localized, extraluminal flow was stopped by direct compression of the pseudoaneurysm itself. Frequently the minimum force required to arrest the flow in the tract and within the injury itself also occluded the femoral artery. This was not considered to be a contraindication for UGCR. Analgesic or sedative medication was not used routinely during the procedure; instead, an attempt was made to distract the patients and to make them feel comfortable by verbal reassurance. Approximately every 15 minutes, a change of operators was undertaken, without releasing the pressure or altering the position of the transducer. After 20 to 30 minutes, pressure was temporarily released every 10 to 15 minutes to check whether the lesion was cured; UGCR was stopped as soon as this was the case. The procedure was also terminated when success could not be obtained within 80 minutes. After the procedure, all patients immediately received a compression bandage and were put on bed rest for 24 hours. Follow-up color-flow examinations were performed 1 to 2 days after the procedure and before discharge of the patient.

In case UGCR failed, false aneurysms that were found to be stable in size were simply observed until they thrombosed spontaneously. In these patients, the compression bandage was also removed after 24 hours; this was followed by strict bed rest for 2 to 3 days and subsequent cautious mobilization.
Lesions that were deemed to be unstable were either treated by percutaneous implantation of collagen plugs or surgery. Statistical calculation was performed by the $\chi^2$ test.\textsuperscript{13}

Taking into consideration multiple analysis (n=5), the customary significance level of $P<.05$ was corrected down to $P<.01$ ($=P<.05/5$) according to the Bonferroni adjustment for multiple comparisons.\textsuperscript{14}

Results

Between January 1992 and January 1994, UGCR was attempted in 53 cases of pseudoaneurysms (35 men and 18 women) and in 9 cases of AV fistulas (6 men and 3 women). Patient age ranged from 29 to 83 years, with an average age of 61 years (median, 61 years). Twenty-three cases occurred after diagnostic heart catheterization, 27 cases after coronary stent implantation, 6 after percutaneous transluminal coronary angioplasty, 1 after His-bundle ablation, 4 after peripheral percutaneous transluminal angioplasty, and 1 after angiography of the celiac trunk. Of the 53 patients with a false aneurysm, 26 were on oral anticoagulants (phenprocoumon) at the time of UGCR (international normalized ratio [INR], 3.5 to 5.5), while none of the patients with an AV fistula were anticoagulated.

All but 11 lesions were identified at the first postprocedural duplex examination 1 to 6 days after the intervention (median, 2 days). In 9 patients, no lesion was apparent at the first follow-up scan 2 days after coronary stent implantation; subsequent check-ups 6 to 17 days (median, 10 days) after the procedure revealed a pseudoaneurysm. Another two pseudoaneurysms were detected during a follow-up examination in the outpatient department 2 and 4 weeks after catheterization of the femoral artery.

All procedures were completed as planned. Upon beginning the procedure, patients frequently complained of discomfort. This diminished greatly, however, once the operator had taken a definitive position and the patient had become accustomed to compression. Occasionally, mild transient vagal reactions occurred, which did not require any specific treatment. No other adverse effects were observed.

False Aneurysms

In patients without anticoagulants, UGCR was performed either on the day the lesion was detected (10 cases) or after a second compression bandage failed to cure the injury (17 cases), resulting in an interval of 0 to 5 days (mean, 1.5 days; median, 1 day) after the diagnosis was made. Patients with coronary stents are maintained on high-intensity oral anticoagulant therapy and aspirin for a period of 6 to 12 weeks at our institution. UGCR was performed in all but one of these patients after stabilization of the INR, usually 5 to 10 days after stent implantation, without interruption of the administration of oral anticoagulants and aspirin; in one case, UGCR was postponed until oral anticoagulants had been stopped.

Ten of the 27 who were not on oral anticoagulants were taking aspirin (100 or 300 mg/d). Permanent cure was obtained in 25 of these 27 patients, resulting in a cure rate of 93% (Table). The 2 patients of this group in whom UGCR failed did not take aspirin or any other platelet-inhibiting drug. One of the patients required two courses of UGCR after premature removal of the compression bandage had resulted in a recurrence of the lesion after the first, initially successful compression maneuver. The compression time until success was obtained ranged between 25 and 60 minutes (mean, 49 minutes; median, 55 minutes).

Patients who were on oral anticoagulants were successfully treated by UGCR in 14 of 26 cases (54%). The INR of these 14 patients was between 2.5 and 6.0 (mean, 3.9; median, 4.5) at the time of compression repair. Temporary success was achieved in 6 additional patients (INR, 3.5 to 6; mean, 4.7; median, 5.0), but the pseudoaneurysms recurred overnight and could not be cured permanently despite a second UGCR attempt. Compression repair failed in 6 patients with an INR of 3.5 to 6.0 (mean, 4.9; median, 5.0). Thus, no significant correlation could be found between the INR at the time of UGCR and therapeutic success.

Neither the size of the pseudoaneurysm (diameter, 5 to 60 mm; mean, 24 mm; median, 21 mm) nor the age of the lesion (0 to 29 days; mean, 9.4 days; median, 6 days) could be discerned as a discriminant predictor of success (Table). The detection of the aneurysmatic tract was also of no predictive value in patients without anticoagulants. In patients on oral anticoagulants, however, there was a positive correlation between the length of the aneurysmatic tract and the success of UGCR: In 24 patients on oral anticoagulants, a communicating channel between the extraluminal cavity and the femoral artery could be detected by duplex scanning; in 2 pseudoaneurysms, the extraluminal cavity was located so close to the femoral artery that no communicating channel could be detected. UGCR was successfully performed on 11 of 12 lesions showing an aneurysmatic tract $\geq$10 mm long. Only 3 of 14 false aneurysms that had a neck $<$10 mm long (0 to 8 mm) could be repaired by UGCR.

In correcting for variables of prognostic importance (anticoagulation, length of the aneurysmatic tract), no

<table>
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<tr>
<th>Success Rate</th>
<th>$P$</th>
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<tr>
<td>No anticoagulants, n (%)</td>
<td>25/27 (93)</td>
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<tr>
<td>Anticoagulants, n (%)</td>
<td>14/26 (54)</td>
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<th>Age of the false aneurysm, d (%)</th>
<th>Success Rate</th>
<th>$P$</th>
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<tr>
<td>$&lt;5$</td>
<td>19/25 (76)</td>
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<tr>
<td>5-20</td>
<td>16/23 (70)</td>
<td>NS</td>
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<tr>
<td>$&gt;20$</td>
<td>4/5 (80)</td>
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<th>Small (volume* $&lt;$8 cm$^3$), n (%)</th>
<th>Success Rate</th>
<th>$P$</th>
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<td>30/40 (75)</td>
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<th>Large (volume* $&gt;$8 cm$^3$), n (%)</th>
<th>Success Rate</th>
<th>$P$</th>
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<td>9/13 (69)</td>
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<th>Short communicating tract (&lt;10 mm), n (%)</th>
<th>Success Rate</th>
<th>$P$</th>
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<td>3/146 (21)</td>
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<th>Long communicating tract (&gt;10 mm), n (%)</th>
<th>Success Rate</th>
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<td>11/125 (92)</td>
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*Volume as defined by the formula length$\times$width$\times$depth. 
†For example, see Fig 3, left. 
‡For example, see Fig 3, right. 
§Patients on anticoagulants only.
learning curve was evident when the first quartile of our patients was compared with the last.

Arterial flow in the underlying artery was completely interrupted during the compression maneuver in 45 cases; this did not affect the success rate, nor did it cause any complications.

Among the 14 false aneurysms that could not be closed by UGCR, 8 thromosed spontaneously within 1 week after anticoagulant therapy was ended, 2 were closed by percutaneous implantation of collagen plugs, and 2 were treated surgically. One patient died of renal failure (6 days after the last follow-up duplex scan), and another patient was discharged with arrangements for clinical follow-up of the pseudoaneurysm (Fig 1).

AV Fistulas

UGCR was also performed on 9 patients with an AV fistula. None of them were on anticoagulants. In 3 cases, the lesion could be repaired by UGCR (compression time, 45 and 60 minutes) (Fig 2). All 3 were characterized by a long channel that was easy to depict and to compress by ultrasound guidance. In the other 6 cases, the artery and the vein were connected directly; permanent cure by UGCR could not be obtained in any of them. One AV fistula obliterated spontaneously 1 month after UGCR. Follow-up scans obtained 1 to 10 months after UGCR showed that the remaining 5 AV fistulas were still persisting but were small and stable in size.

All UGCR attempts on AV fistulas included temporary complete occlusion of the lumen of the femoral artery and vein without any resulting complications.

Discussion

Because of altered anticoagulation regimes and larger-size percutaneous instruments, the incidence of local complications following percutaneous femoral catheterization has increased in the past few years. Recent studies have shown a false aneurysm rate of 1.6% after cardiac catheterization and 0.7% to 6.3% after percutaneous transluminal coronary angioplasty.15-20 In addition, it has been suggested that pseudoaneurysms and AV fistulas may be detected more frequently when patients are examined routinely with color-flow duplex ultrasound after invasive procedures.3,11,12,21

The common treatment for false aneurysms has been surgical repair,18,22,23 since they may lead to infection, compression neuropathy, rupture, progressive enlargement, and blood loss, while large AV fistulas may cause congestive heart failure and progressive dilatation of the veins draining the lesion. In 1986, Cope and Zeit24 described the coagulation of pseudoaneurysms by direct percutaneous thrombin injection. This method, however, requires the elimination of blood flow into the extraluminal cavity.

Fellmeth et al.14,25 introduced color-flow duplex ultrasound compression repair as a method for inducing thrombosis of the lesion by direct compression on the tract of the pseudoaneurysm or the AV fistula.

In their original report, Fellmeth and Roberts1 reported a series of 29 postcatheterization injuries (27 pseudoaneurysms and 2 AV fistulas) that had been treated by this method; 26 false aneurysms and 1 AV fistula had been successfully repaired by UGCR. Subsequent reports on this method confirmed the advantages such as a high success rate, low morbidity, and cost-effectiveness.3-9 Thus, UGCR has proved to be an effective tool for noninvasive therapy of local complications after catheterization of the femoral artery.
While our study further corroborates these results with a success rate of 93% in patients without anticoagulation, our criteria for indications and performance of UGCR differed in several aspects from those of the other authors mentioned above, major issues being the use of anticoagulants, concomitant compression of the femoral artery, and the age of the lesion.

There have been sporadic previous reports about successful UGCR in patients on oral anticoagulant therapy, but anticoagulants were either withheld before UGCR or given at moderate doses only, with a prothrombin ratio ranging from 1.3 to 1.8. Of our patients, 26 were on simultaneous aspirin therapy and intensive oral anticoagulation therapy, with an INR ranging from 2.5 to 6.0. Neither aspirin nor phenprocoumon was withheld for UGCR; 14 of 26 patients on oral anticoagulants (54%) were successfully treated by this method (Table). Although the success rate of UGCR is lower in patients who are on oral anticoagulants, we believe it is good enough to justify an attempt with UGCR also in patients on anticoagulants, especially if one considers the risks of alternative procedures, such as surgery or awaiting spontaneous thrombosis.

In 45 of our patients, the vascular lesion could be compressed completely only with simultaneous temporary occlusion of the underlying femoral artery and vein. This has generally been regarded to be a contraindication for continuing the procedure after the report of a case of subacute occlusion of the femoral artery under these conditions (Fellmeth and Roberts). We observed no such complication in any of the 45 patients in whom UGCR resulted in complete compression of the femoral artery and vein; therefore, we do not consider the need for simultaneous compression of the large femoral vessels to be a contraindication to UGCR.

"Longstanding" lesions have been reported to be unsuitable for UGCR. We attempted UGCR in 3 patients with pseudoaneurysms that were even older than 4 weeks (29, 32, and 59 days after catheterization of the femoral artery). All of them could be successfully repaired (Table). Therefore, "chronic" lesions should not be excluded from a UGCR attempt.

While the intensity of anticoagulation (INR, 2.5 to 6) was not a prognostic factor for the success of the procedure in patients who were on anticoagulants, the length of the communicating tract proved to be predictive (Fig 3). False aneurysms with an aneurysmatic tract >10 mm long could be permanently occluded by UGCR in 11 cases, whereas only 3 lesions with a communicating channel <10 mm long were successfully treated by this method (Table).

AV fistulas have rarely been treated with UGCR and until now with little success. We were successful in 3 of 9 cases; all 3 were characterized by a long communicating channel between the femoral artery and the vein, whereas no communicating tract could be found in the remaining patients.

In conclusion, we consider UGCR to be the technique of first choice for the treatment of postcatheterization femoral artery injuries, even in patients on anticoagulants. Our results additionally suggest that lesions can be treated by this method irrespective of size and age, even when the femoral artery has to be compressed simultaneously.
References


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