Pseudoaneurysm of the femoral artery after cardiac catheterisation: diagnosis and treatment by manual compression guided by Doppler colour flow imaging

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Abstract
Objective—To assess the value of Doppler colour flow imaging for diagnosing and guiding non-surgical treatment of pseudoaneurysm of the femoral artery complicating cardiac catheterisation.

Design—A prospective study.

Setting—Cardiac department in a teaching hospital.

Patients—9 patients (8 female, 1 male) who presented with pseudoaneurysm 1–15 days after cardiac catheterisation.

Interventions—The femoral arterial communication to the false aneurysm was localised by Doppler colour flow imaging. Manual pressure was then applied to the ultrasound transducer which was positioned directly over the site of the arterial communication. Pressure was progressively increased until it was sufficient to prevent colour flow from the artery into the false aneurysm cavity while allowing Doppler flow to continue within the arterial lumen.

Main outcome measures—Characteristics of pseudoaneurysm, duration of manual compression, success rate, follow up.

Results—The pseudoaneurysms ranged from 1·3 to 5·5 cm in length. Six pseudoaneurysms were 1·3–2·0 cm away from the arterial puncture. The pseudoaneurysm was closed in 8/9 patients by compression exerted manually through the transducer for 25–40 minutes (3 successful cases required two or three periods of compression within 48 hours). No pseudoaneurysm recurred during 14–61 days of follow up.

Conclusions—Most pseudoaneurysms of the femoral artery can be treated by a period of manual pressure applied with an ultrasound transducer and guided by Doppler colour flow.

Patients and methods

Patients
In a 13 month period during which there were 1540 cardiac catheterisations at the Western General Hospital, 12 patients with painful swollen haematomas in the groin after cardiac catheterisation were scanned. In four (0·3%) there was a haematoma but no pseudoaneurysm. The other eight (0·5%) each had a false aneurysm. Another patient (case 6) in whom a pseudoaneurysm of the femoral artery developed after cardiac catheterisation at another hospital is also reported in this series.

Of the nine patients with pseudoaneurysm (table 1) eight were women and six of them were slim. The women were 43–76 years old and had undergone cardiac catheterisation via a 6 or 7 F sheath in the right femoral artery. Patient number 7 was a 66 year old man in whom a pseudoaneurysm developed 2 weeks after coronary balloon angioplasty and stent implantation (via an 8F femoral sheath). The systolic blood pressure in four of the patients was >170 mm Hg at the time of catheterisation while the pulse pressure in seven patients was >70 mm Hg (table 1).

Eight patients were taking aspirin and four patients were taking warfarin (stopped 2 days
before the catheterisation in three cases). Two patients (numbers 7 and 8) had a prothrombin time ratio >2.5 on the day that their pseudoaneurysm was treated. A F8 sheath was placed in the ipsilateral femoral vein in two patients—including case 2 who underwent balloon dilatation of the mitral valve and received heparin (100 units/kg) intravenously after transseptal puncture.

CLINICAL PRESENTATION

Seven patients had needed prolonged manual compression (that is, at least 20 minutes) to stop bleeding after the femoral sheath was removed. All patients had become aware of a painful haematoma in the groin within 48 hours of cardiac catheterisation. A localised region of pulsation was apparent within the haematoma in six of them but in three a pseudoaneurysm was initially considered unlikely on clinical examination. Two patients were first treated by bed-rest (for 2 and 4 days) before an ultrasound scan was performed.

Table 1 Clinical details of patients

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>BP (mm Hg)</th>
<th>Gauge of femoral arterial lumen</th>
<th>Sheath in femoral vein</th>
<th>Drug treatment</th>
<th>Body Weight (kg)</th>
<th>Body mass index (kg m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>F</td>
<td>IHD</td>
<td>180/80</td>
<td>F6</td>
<td>No</td>
<td>Aspirin</td>
<td>65</td>
<td>25</td>
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<td>2</td>
<td>76</td>
<td>F</td>
<td>MVD</td>
<td>120/70</td>
<td>F6</td>
<td>Yes</td>
<td>Warfarin</td>
<td>51</td>
<td>23</td>
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<td>3</td>
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<td>180/100</td>
<td>F6</td>
<td>Yes</td>
<td>Warfarin/aspirin</td>
<td>57</td>
<td>23</td>
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<tr>
<td>4</td>
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<td>F</td>
<td>IHD</td>
<td>175/80</td>
<td>F6</td>
<td>No</td>
<td>Aspirin</td>
<td>57</td>
<td>25</td>
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<td>5</td>
<td>43</td>
<td>F</td>
<td>IHD</td>
<td>175/100</td>
<td>F6</td>
<td>No</td>
<td>Aspirin</td>
<td>64</td>
<td>25</td>
</tr>
<tr>
<td>6*</td>
<td>58</td>
<td>F</td>
<td>Non-cardiac</td>
<td>110/70</td>
<td>F7</td>
<td>No</td>
<td>Aspirin</td>
<td>50</td>
<td>20</td>
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<td>66</td>
<td>M</td>
<td>IHD</td>
<td>130/35</td>
<td>F8</td>
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<td>Warfarin/aspirin</td>
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<td>29</td>
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<td>F6</td>
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<td>30</td>
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<td>F6</td>
<td>No</td>
<td>Aspirin</td>
<td>76</td>
<td>32</td>
</tr>
</tbody>
</table>

IHD, ischaemic heart disease; MVD, mitral valve disease; * Patient referred for treatment from another hospital; prothrombin time ratio >2.5 when pseudoaneurysm treated.

DIAGNOSIS OF PSEUDOANEURYSM OF THE FEMORAL ARTERY

We performed ultrasound scans of the femoral puncture site in any patient in whom a significant groin swelling developed after catheterisation, using an Advanced Technology Systems Ultramark 9 Ultrasound System with a 2-25 MHz phased array transducer. The depth was usually adjusted to the minimum of the range (4-0 cm). The transducer was placed over the femoral puncture site so that the femoral artery was imaged in the longitudinal plane. Gain was reduced until the arterial lumen was free of echoes. The colour Doppler gain was then adjusted until the pulsatile flow in the arterial lumen could be seen but the surrounding subcutaneous tissue remained virtually free of colour. It was possible to visualise clearly the common femoral artery and its bifurcation into its superficial femoral and profunda femoris branches.

All regions of swelling, firmness, or pulsation surrounding the puncture site were sys-
Figure 2  Colour Doppler scan showing a pseudoaneurysm cavity communicating with a
defect in the common femoral artery just proximal to its bifurcation.

Figure 3  A continuous wave Doppler recording from the anterior aspect of a
pseudoaneurysm of the common femoral artery showing the typical "to-and-fro" signal.

METHOD FOR CLOSING FALSE ANEURYSMS
The groin was cleaned with povidone-iodine

MSP 10% solution (Betadine) and at least 20 ml of 2% lignocaine solution was infiltrated
in the subcutaneous tissue surrounding the false aneurysm. Five patients were given addi-
tional analgesia: two intravenous morphine (5 mg), one sublingual buprenorphine
(0-2 mg), and two oral paracetamol (1 g).

Using colour flow Doppler for guidance we positioned the ultrasound transducer pre-
cisely over the defect in the wall of the femoral artery (fig 4). We exerted sufficient
manual pressure on the transducer probe, which was directly over the artery, until
Doppler colour flow from the artery into the false aneurysm cavity ceased and colour flow
pulsations along the arterial lumen continued. Constant manual pressure was maintained for
about 25 minutes; then the pressure was gradually released while the false aneurysm
cavity and the defect in the artery were care-
fully scanned for a Doppler colour flow signal
(that is, a persistent leak). If the pseudoa-
neurysm had not closed then manual pressure
was applied for a further 5–10 minutes before
the pressure was gradually released again and
the region was scanned for a persistent colour
flow signal. If required, the procedure was
continued for up to 50 minutes but pro-
longed manual compression was limited by the
fatigue of the investigator or the patient or
both. If the procedure failed a second attempt
was made within 24 hours.

In one patient (case 6) we used a
FemoStop inflatable mechanical device (Radi-
medic Systems, UK) to compress the pseudo-
aneurysm for 60 minutes. This second attempt
at compression was unsuccessful. In two
patients the FemoStop was applied for 1–4
hours to prevent a recurrence after initial closure
of the pseudoaneurysm by manual compression.
If the aneurysm was closed the patient was
kept on bed rest until the next day, when an
ultrasound scan was repeated. If there was no
recurrence of the pseudoaneurysm the patient
was discharged home.

Results
ULTRASOUND APPEARANCE OF
PSEUDOANEURYSMS
Ultrasound imaging showed six spherical
(1·3–3·5 cm diameter) and three large ovoid
/about 2·5 × 5·0 cm) pseudoaneurysms (table
2). One patient (case 4) needed prolonged
scanning of the haematoma to locate the pseudoaneurysm cavity. Only three pseudo-
aneurysms were directly anterior to the arteri-
al puncture site whereas the other lesions
were lateral or distal to it (table 2).

In all patients colour Doppler identified a
channel connecting the cavity of the false
aneurysm to the arterial puncture site. The
puncture site was in the anterior wall of the
common femoral artery in seven cases. In one
case the lateral aspect of the common femoral
artery had been punctured—the arterial
puncture site in this patient (case 4) was
located with some difficulty by following the
connecting tract back to the arterial lumen
from the cavity of the false aneurysm. The
Figure 4 Technique for non-surgical closure of pseudoaneurysm of the femoral artery. (A) The transducer is positioned directly over the defect in the femoral artery (which may be displaced from the aneurysm cavity). (B) The artery is compressed so that flow into the cavity ceases while flow within the arterial lumen is maintained.

Table 2 Characteristics of pseudoaneurysms and outcome of non-surgical closure

<table>
<thead>
<tr>
<th>Case No</th>
<th>Shape of PA</th>
<th>Size of PA (cm)</th>
<th>Relation of PA to puncture in artery</th>
<th>Site of puncture in artery</th>
<th>Timing of treatment (days)</th>
<th>Duration of compression (months)</th>
<th>Success</th>
<th>Follow up (days)</th>
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<tbody>
<tr>
<td>1</td>
<td>Spherical</td>
<td>1.8</td>
<td>Anterior</td>
<td>Anterior</td>
<td>4</td>
<td>35</td>
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<td>49</td>
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<tr>
<td>2</td>
<td>Spherical</td>
<td>2.3</td>
<td>1-3 cm distal</td>
<td>Anterior</td>
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<td>25</td>
<td>Yes</td>
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<tr>
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<td>1.5</td>
<td>2-0 cm distal</td>
<td>Anterior</td>
<td>1</td>
<td>30 and 40§</td>
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<td>26</td>
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<tr>
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<td>2.2</td>
<td>2-0 cm distal</td>
<td>Lateral</td>
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<td>25 and 35§</td>
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<td>61</td>
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<tr>
<td>5</td>
<td>Ovoid</td>
<td>4-3 x 2-3</td>
<td>Anterior</td>
<td>Anterior</td>
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<td>30</td>
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<td>41</td>
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<tr>
<td>6</td>
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<td>4.0 x 2.2</td>
<td>2-0 cm distal</td>
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<td>50 and 60§</td>
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<td>Anterior</td>
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<td>30</td>
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<td>55</td>
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<td>55</td>
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<tr>
<td>9</td>
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<td>1-5 cm distal</td>
<td>Anterior</td>
<td>1</td>
<td>30§</td>
<td>Yes</td>
<td>20</td>
</tr>
</tbody>
</table>

PA, pseudoaneurysm. *Measurement relative to midpoint of pseudoaneurysm cavity; †all punctures were in the common femoral artery; ‡relative to cardiac catheterisation; §closed only by further periods of manual compression; ¶treatment assisted by mechanical compression using the FemoStop device; S, patient treated by vascular surgery.

arterial puncture was in the medial wall of the common femoral artery in patient 8.

NON-SURGICAL CLOSURE OF PSEUDOANEURYSMS

Non-surgical closure of a pseudoaneurysm was attempted on the day after catheterisation in five patients and on days 2, 4, 4, or 15 in the other four. Doppler guided manual compression applied with the transducer to the arterial puncture sites for initial periods of 25–50 minutes (table 2) closed five of the lesions. In three patients (in which initial compression was unsuccessful) manual compression was applied (successfully) for a further period of 35–40 minutes within 24 hours of the first attempt; patient 8 had a third period of manual compression because the pseudoaneurysm recurred the next day. Initially we failed to close these three false aneurysms because it was difficult to maintain sufficient continuous pressure at the correct point—especially in patients 4 and 8 in whom the lateral or medial aspect of the femoral artery was punctured. Each time a false aneurysm had sealed there was no recurrence of pain at the site.

In four patients a cavity was still apparent after the arterial puncture site had sealed but this was non-pulsatile and there was no evidence of colour flow within it. In the other four patients thrombosis of the pseudoaneurysm cavity was seen after closure of the arterial puncture. No pseudoaneurysm recurred during follow up for 14–61 days (table 2) and two patients (1 and 4) subsequently underwent coronary angioplasty through the site of the previous pseudoaneurysm without difficulty.

Non-surgical closure of the pseudoaneurysm in patient 6 (treated at another hospital) was unsuccessful: the first period of 50 minutes manual compression failed to seal the pseudoaneurysm—mainly because a large surrounding haematoma made it difficult to maintain constant accurate positioning of the compression. Despite a second period of mechanical compression (with a FemoStop device) for 60 minutes on the next day the pseudoaneurysm still did not close: when the FemoStop was in position we could not obtain a clear ultrasound image of the artery to ensure that the leakage of blood from the artery was under control. In patient 6 the femoral artery was surgically repaired.
Discussion
We found that ultrasound imaging with colour flow Doppler was a valuable technique for determining the nature of swellings in the groin after cardiac catheterisation. In some patients the precise diagnosis cannot be made from clinical examination alone. It is possible that some pseudoaneurysms are wrongly diagnosed as haematomas when ultrasound is not used. It is also possible that some false aneurysms close spontaneously. Usually colour flow Doppler showed flow into the aneurysm cavity and it was easy to distinguish between a pseudoaneurysm and a haematoma. However, our fourth patient showed that prolonged and careful scanning may be necessary to ensure that a pseudoaneurysm is not overlooked.

Eight of the patients treated were female; others found a higher incidence of pseudoaneurysms in women.\(^3\) Hypertension may also predispose to pseudoaneurysm: four patients had a systolic blood pressure \(>170\) mm Hg and seven had a pulse pressure of \(>70\) mm Hg. Although femoral artery complications are often considered to be commoner in obese patients only three of our patients had a body mass index \(>25\) kg m\(^{-2}\). It has been suggested that false aneurysms are more likely to occur if the superficial femoral artery has been punctured; this did not occur in our patients—all nine were associated with puncture of the common femoral artery.

The fact that compression was successful in eight of nine patients suggests that it is worth attempting to close all false femoral artery aneurysms using this technique guided by colour flow Doppler. Our series also suggests that a further attempt to close the lesion is indicated if the first attempt fails. Firm pressure on a false aneurysm can be very painful but the procedure was well tolerated when adequate local anaesthesia (and sometimes additional analgesic) was given.

It is not yet clear how often this technique would be successful in a larger series of cases. An F6 femoral sheath had been used in seven of the patients in whom compression was successful, and the false aneurysms were small. We believe that collection by compression should be attempted in any patient with post-catheterisation false aneurysm, and that only those in whom the non-surgical technique is unsuccessful should have surgical repair. This view is supported by recent reports of high success rates for closure of false aneurysms by direct pressure with a C-clamp (100\%?) or indirect manual pressure with the ultrasound transducer (73\%).

It is possible that manual pressure over the aneurysm without simultaneous colour Doppler imaging might have been successful in our cases. The use of ultrasound, however, indicated the degree of pressure required to prevent flow into the aneurysm. Even intermittent egress of blood through the puncture site in the artery may prevent sealing. Further, in six cases the aneurysm cavity lay some distance from the the defect in the artery and pressure applied generally to the swelling in the groin without ultrasound guidance would have been suboptimally positioned. In two patients the defect was in the side wall of the artery and it was difficult to apply pressure at the correct position. It was also helpful to be able to observe normal flow along the arterial lumen during the period of pressure, allowing longer compression time without creating peripheral ischaemia.

Before the introduction of this new treatment these patients would have been referred to a vascular surgeon and would have undergone surgical repair with a longer hospital stay and convalescence. Ultrasound guided compression seems to be a useful treatment for closure of false aneurysms of the femoral artery and the importance of this procedure will increase if the growing use of complex techniques of interventional coronary angioplasty increases the frequency of false aneurysms of the femoral artery.