MEASUREMENT OF FEMORAL VEIN BLOOD FLOW DURING TOTAL HIP REPLACEMENT

DUPLEX ULTRASOUND IMAGING WITH AND WITHOUT THE USE OF A FOOT PUMP

DAVID WARCK, A. G. MARTIN, D. GLEW, G. C. BANNISTER

From the University of Bristol and the Avon Orthopaedic Centre, Bristol, England

We examined ten femoral veins with duplex ultrasound during total hip replacement to demonstrate the operative manoeuvres which cause venous obstruction and to assess prophylactic measures which may overcome it.

Exposure of the acetabulum by distraction of the femur with a hook was less likely to occlude flow than retraction with bone levers. Adequate exposure of the femoral shaft by adduction, flexion and either internal or external rotation caused cessation of flow in all cases. In four cases an A-V Impulse System foot pump was activated during periods of stasis. In each case it overcame the obstruction and produced peak velocities which were twice that of the resting state.

In five cases, towards the end of the procedure, debris was seen travelling proximally through the femoral vein.

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Without prophylaxis, 25% to 29% of patients having a total hip replacement will develop ipsilateral proximal venous thromboses (Nilius and Nylander 1979; Kålebo et al 1990). Such thromboses are almost unique to this procedure and are rarely seen in other patients (Nylander and Olivecrona 1976). The thrombi form in valve pockets (Sevitt 1974) and predispose to pulmonary embolism (Havig 1977; Norris, Greenfield and Herrmann 1985).

Vircow described three interrelated factors which could result in venous thrombosis: vessel wall damage, altered coagulation factors, and venous stasis. Vessel wall damage has not been reported after total hip replacement, but altered coagulation does occur. Bone resection during total hip replacement is a potent source of thromboplastins which initiate hypercoagulability and impaired fibrinolysis (Dahl et al 1993). Venous stasis has been shown indirectly by venographic and cadaver studies (Stamatakis et al 1977; Johnson et al 1978; Binns and Pho 1990; Planèse, Vochelle and Fagola 1990), but no direct evidence of altered flow in the femoral vein has been reported. Demonstration of venous stasis requires either intraluminal monitoring or the use of duplex ultrasound. Intraluminal monitoring is invasive and available only as a research tool, while duplex ultrasound is readily available, although it requires an experienced operator. A probe placed against the skin can determine the direction and rate of flow in an underlying vessel.

Venous stasis can be reduced by the use of the A-V Impulse System foot pump (Novamedix, Andover, UK). This device stimulates the physiological venous plexus in the foot, displacing a column of blood through the deep venous system towards the heart (Gardner and Fox 1989). The increased flow causes turbulence in the venous valve cusps, flushing out the sites where thrombi are thought to form (Sevitt and Gallagher 1961; Nicolaides et al 1972). A number of reports have shown a dramatic reduction in overall and particularly proximal deep venous thrombosis in clinical trials (Table I).

We aimed to demonstrate by ultrasound whether the operative manoeuvres required for total hip replacement caused femoral vein stasis, and if so, whether these could be overcome by the A-V Impulse System foot pump.

PATIENTS AND METHODS

We imaged ten femoral veins in nine patients undergoing primary total hip replacement. The study had the approval of the Ethical Committee and the patients gave informed consent. No patient had a history of venous disease. The operations were carried out under combined general and spinal anaesthesia. A cemented prosthesis was implanted through a posterior approach in all cases.

Imaging. An Ultramark 9 Duplex Scanner (ATL, Bothell,
Table I. Published randomised studies of the A-V Impulse System after total hip replacement

<table>
<thead>
<tr>
<th>Author</th>
<th>Control Additional method</th>
<th>Total DVT No</th>
<th>Proximal DVT No</th>
<th>Foot pump Additional method</th>
<th>Total DVT No</th>
<th>Proximal DVT No</th>
<th>p value</th>
<th>Pump started</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fordyce and Ling (1992)</td>
<td>Stockings</td>
<td>40</td>
<td>16</td>
<td>40</td>
<td>39</td>
<td>10.3</td>
<td>&lt; 0.001</td>
<td>Postop</td>
</tr>
<tr>
<td>Bradley, Krugener and Jager (1993)</td>
<td>Stockings Heparin</td>
<td>44</td>
<td>12</td>
<td>27.3</td>
<td>30</td>
<td>6.7</td>
<td>&lt; 0.025</td>
<td>Induction of anaesthesia</td>
</tr>
<tr>
<td>Santori et al (1994)</td>
<td>Stockings Heparin</td>
<td>65</td>
<td>23</td>
<td>35.4</td>
<td>67</td>
<td>13.4</td>
<td>&lt; 0.005</td>
<td>Postop</td>
</tr>
</tbody>
</table>

Washington) with a 5 MHz probe was used. The position of the femoral vein was identified by real-time ultrasound and marked with ink. The patients were then placed in the lateral position and draped so that the site of the femoral vein could be accessed without compromising wound sterility. The blood flow was then measured as follows: 1) before incision and after resection of the femoral head, with the limb in neutral orientation in all planes; 2) during exposure of the acetabulum, using either a hook in the greater trochanter to distract the femur or bone levers over the margin of the acetabulum to retract the femur; 3) during exposure of the femoral medulla with flexion, adduction and either internal rotation (posterior approach) or external rotation (anterolateral approach); both these positions were reproduced in all ten cases; and 4) after the operation, with the limb in neutral position.

The accuracy of the measured velocity of flow depends on the precise position of the Doppler probe, accurate measurement of the angle between the probe and the Doppler signal, and the diameter of the femoral vein, which varies at different points of the flow cycle. We therefore calculated the factor between peak and mean velocities rather than the true velocity.

**Foot pump.** In four patients the A-V Impulse System foot pump was applied to the foot before draping the leg and starting the operation. The pump was activated for a short period in each of the positions listed above to demonstrate its effect on venous flow.

**RESULTS**

**Femoral vein flow.** There was no difference in flow before or after neck resection of the femoral head provided that the femur was held in the neutral position in all planes. Distraction of the femoral shaft with a hook in the greater trochanter allowed partial flow in three cases and none in the other seven. Leverage on a bone lever placed over the anterior rim of the acetabulum to retract the proximal femur occluded femoral venous flow in all cases. Sufficient flexion, adduction and internal rotation (posterior approach) or external rotation (anterolateral approach) to obtain access to the femoral medulla caused complete cessation of venous flow in all cases. We found no significant differences in venous obstruction between the two approaches.

The flow returned to its original state in all cases immediately after completion and reduction of the hip replacement.

**Foot pump.** Activation of the foot pump overcame the obstruction caused by the various manoeuvres in all four legs in which it was used. The peak velocities recorded were twice the resting velocities.

Particulate debris was visualised travelling proximally through the femoral vein towards the end of the procedure in two of the patients in whom the foot pump was used and in three in whom it was not.

**DISCUSSION**

Our study provides direct evidence of the dynamic changes in femoral venous flow during total hip replacement. Intraoperative venography in nine cases (Stamatakis et al 1977; Johnson et al 1978) showed distortion of the intraluminal column of contrast in the femoral vein after dislocation, with apparent slowing of the flow of the contrast medium. Planè et al (1990) examined the dissected femoral veins of ten cadavers in simulated positions of peroperative hip dislocation, demonstrating that flexion and adduction of the thigh produced folding of the femoral vein. In another cadaver study of 20 specimens, Binns and Pho (1990) observed the cessation of flow of an intravenous saline infusion with adduction and flexion of the dislocated hip. They then injected the femoral vein with acrylic in the position at which flow had ceased; after dissection and corrosion the specimens showed buckling of the vein. These cadaver studies were limited by the loss of normal venous tone and arterial inflow, and none of them addressed possible changes in the femoral vein during retraction for acetabular preparation.

McNally and Mollan (1993) used strain-gauge plethysmography to investigate venous outflow from the leg after total hip replacement, and identified a reduction in outflow which persisted for at least six weeks after operation. This prolonged reduction suggests that there...
may be an alteration in venous physiology in addition to the temporary venous occlusion shown in our study.

Our results provide some guidance on possible methods of reducing disruption to blood flow in the femoral vein and thus to reduce the potential risk of proximal thrombosis. Resection of the femoral head and neck did not affect flow: this was fully maintained when the femoral shaft was in neutral orientation in all planes. This position should be adopted whenever possible, between periods in which bone preparation or prosthesis implantation are taking place. For access to the acetabulum, distraction with a bone hook on the greater trochanter was less likely to cause occlusion than retraction with levers; the former method is therefore recommended. We found it impossible to gain adequate access to the medullary cavity of the femur without completely occluding venous flow, and therefore recommend that the time during which the femoral cavity is fully exposed should be limited as far as possible. It has been suggested that cementless total hip replacement carries less risk of thrombosis (Francis, Marder and Evarts 1986; Kim and Suh 1988), possibly because it requires less prolonged distortion of the femoral vein. We found that the choice of anterolateral or posterior approaches had no influence on the disruption of femoral vein flow.

Prophylaxis against thrombosis in total hip replacement is a controversial topic. Meta-analysis shows that the use of unfractionated and low-molecular-weight heparins does reduce the incidence of overall and proximal thromboses (Table II; Collins et al 1988; Bergqvist 1992; Jorgensen, Wille-Jorgensen and Hauch 1993). Despite these findings many orthopaedic surgeons are reluctant to use chemical prophylaxis because of the risk of haemorrhagic complications (Paiement, Wessinger and Harris 1987; Owen and Coors 1992). Published randomised studies of the use of the A-V Impulse foot pump after total hip replacement show a reduction in thrombosis, especially in the proximal veins (Table I). In two of the three studies, the foot pump was activated immediately after the operation. A randomised study is now required to show whether the demonstrated ability of the foot pump to overcome venous occlusion during the operation will provide a further reduction in the rate of venous thrombosis.

The significance of the debris which we demonstrated in half of our cases is not clear. Transoesophageal echocardiography has shown similar particulate matter in the heart during total hip replacement (Propst et al 1993) and hemiarthroplasty (Christie et al 1994). Animal studies have shown this to comprise mixed emboli of bone marrow and thrombotic material (Wenda et al 1990). Further studies are required on this debris and its relationship to thromboembolism.

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REFERENCES


Table II. Meta-analysis of published randomised trials of thromboprophylaxis after total hip replacement (after Collins et al 1988; Bergqvist 1992; Jorgensen et al 1993)

<table>
<thead>
<tr>
<th>Percentage of thromboses</th>
<th>Total</th>
<th>Proximal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>42</td>
<td>24</td>
</tr>
<tr>
<td>Standard heparin</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Low-molecular-weight heparin</td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>

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Wenda K, Ritter G, Ahlers J, von Issendorff WD. Detection and effects of bone marrow intravasations in operations in the area of the femoral marrow cavity. *Unfallchirurg* 1990; 93:56-61. [In German].