DEEP VEIN THROMBOSIS AFTER ELECTIVE KNEE SURGERY

AN INCIDENCE STUDY IN 312 PATIENTS

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The incidence of venous thromboembolism after elective knee surgery has previously been studied almost exclusively in patients receiving total knee replacements, in whom the risk of a deep vein thrombosis is approximately 60%. We report the results of ipsilateral ascending venography in 312 patients undergoing a wide variety of elective knee operations under tourniquet ischaemia, none of whom received any specific prophylaxis against thromboembolism.

Total knee replacement was confirmed to carry a high risk with ipsilateral deep vein thrombosis in 56.4% and symptomatic pulmonary embolism in 1.9%. By contrast, arthroscopy was associated with a low incidence of venous thrombosis (4.2%). Meniscectomy, arthrotomy, patellectomy, synovectomy and arthrodesis were all high-risk procedures, particularly in patients over 40 years of age, and were associated with deep vein thrombosis rates of 25% to 67%. On the basis of these findings, we advise prophylaxis against venous thromboembolism in all patients over 40 years of age undergoing elective knee surgery other than arthroscopy.

After Sevitt and Gallagher's original observations on injured patients in 1959, venous thromboembolism has been recognised as a major cause of morbidity and mortality in both emergency and elective orthopaedic surgery. Total hip replacement is associated with a 51% incidence of deep vein thrombosis (DVT) in the operated limb (Stamatakis et al. 1977) and pulmonary embolism (PE) remains the largest single cause of mortality after this operation (Johnson, Green and Charnley 1977). Relatively little is known of the risks involved after knee surgery and the few studies that have been performed have dealt almost exclusively with total knee replacement, where the incidence of DVT was approximately 59% (Stulberg et al. 1984).

We undertook a prospective study to determine the incidence of DVT following a wide variety of elective operations on the knee performed under tourniquet ischaemia. Such a study is essential before the necessity for prophylaxis can be defined.

PATIENTS AND METHODS

A total of 323 consecutive patients undergoing elective knee operations for non-malignant conditions were entered into the study. All patients were interviewed on the day before operation and gave informed consent. Patients were specifically questioned about a previous history of DVT or PE, previous surgery or trauma to the limb concerned, and the use of oral contraceptives. They were examined for evidence of lower limb venous disease (varicose veins or venous ulceration) and their weight and height were recorded. No specific prophylactic measures against postoperative venous thromboembolism were employed.

At operation, under general or epidural anaesthesia, the limb was exsanguinated by elevation alone, Esmarch bandage or by a graduated compression device according to the surgeon's preference. A pneumatic thigh tourniquet was then applied and inflated to a pressure of 500 mmHg. The duration of the operation was recorded together with the type of postoperative dressing (bandage or plaster).

Ascending venography was performed on the
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operated limb seven to 10 days postoperatively. The technique has been described in detail elsewhere (Kakkar 1969) and enables visualisation of calf, popliteal, femoral and iliac veins. Thrombi confined to the calf were classified as 'minor' if less than 5 cm in length and 'major' if more extensive. Popliteal and femoral thrombi were classified as 'proximal' DVTs (Fig. 1). Any patient with symptoms suggestive of pulmonary embolism had a radio-isotope ventilation-perfusion lung scan. Pulmonary emboli were diagnosed on the basis of a segmental or larger perfusion defect accompanied by normal ventilation.

Statistical analysis was by the chi-squared test, Student's t-test and the Mann-Whitney U-test.

RESULTS

Of the 323 patients entered into the study, 11 were subsequently withdrawn: two were allergic to iodine-containing contrast media, venography was unsuccessful in two, two other patients were too ill to be transferred for venography, and five patients refused to participate. Thus 312 patients (222 male: 90 female) ranging in age from 15 to 87 years were available. Analysis was performed in four operative categories: total knee replacement (55 patients), arthroscopy (48), open meniscectomy (151), and miscellaneous (58). The latter group included arthrotomy for removal of loose bodies or synovial biopsy (45 patients), arthrodesis (6), patellectomy (4) and synovectomy (3). Clinical and operative details of the patients are given in Tables I and II. Most of the total knee arthroplasties (42 of 55) were of the Attenborough semi-constrained type.

In all, 88 DVTs were diagnosed, giving an overall incidence of 28.2%. Of these, 44 (50%) were major calf thrombi >5 cm in length and a further 11 (12.5%)

Table I. Clinical details of 312 patients investigated after elective knee surgery

<table>
<thead>
<tr>
<th></th>
<th>Total knee arthroplasty (n = 55)</th>
<th>Arthroscopy (n = 48)</th>
<th>Open meniscectomy (n = 151)</th>
<th>Miscellaneous* (n = 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>64.5 ± 9.8</td>
<td>32.6 ± 12.9</td>
<td>32.9 ± 11.3</td>
<td>34.8 ± 16.9</td>
</tr>
<tr>
<td>Sex (male:female)</td>
<td>14:41</td>
<td>37:11</td>
<td>128:23</td>
<td>43:15</td>
</tr>
<tr>
<td>Mean obesity index (W/H²)</td>
<td>24.5(n = 38)</td>
<td>22.4(n = 21)</td>
<td>23.5(n = 112)</td>
<td>24.1(n = 46)</td>
</tr>
<tr>
<td>Clinical history (per cent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DVT/PE</td>
<td>31</td>
<td>6.3</td>
<td>1.4</td>
<td>5.3</td>
</tr>
<tr>
<td>Trauma to same limb</td>
<td>7.4</td>
<td>14.9</td>
<td>26.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Previous surgery to limb</td>
<td>26.9</td>
<td>28.3</td>
<td>14.2</td>
<td>27.8</td>
</tr>
<tr>
<td>Varicose veins</td>
<td>17.3</td>
<td>0</td>
<td>6.7</td>
<td>0</td>
</tr>
<tr>
<td>Venous ulcers</td>
<td>9.4</td>
<td>0</td>
<td>1.4</td>
<td>0</td>
</tr>
<tr>
<td>On contraceptive pill</td>
<td>0</td>
<td>6.3</td>
<td>1.3</td>
<td>6.9</td>
</tr>
</tbody>
</table>

* See Table III
Iliac
Femoral
Popliteal
Calf

Minor
33
(37.5%)

Major
44
(50%)

Proximal
6
(6.8%)

5
(5.7%)

Fig. 2

Distribution of 88 DVTs in the operated limbs of 312 patients after elective knee surgery.

Table II. Operative details of 312 patients investigated after elective knee surgery

<table>
<thead>
<tr>
<th>Method of exsanguination (Esmarch: elevation/ bandage) (per cent)</th>
<th>Total knee arthroplasty (n = 55)</th>
<th>Arthroscopy (n = 48)</th>
<th>Open meniscectomy (n = 151)</th>
<th>Miscellaneous* (n = 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>67.4:32.6</td>
<td>38.7:61.3</td>
<td>85.1:14.9</td>
<td>59.41</td>
</tr>
<tr>
<td>Duration of operation (minutes)</td>
<td>85 ± 13</td>
<td>35 ± 13</td>
<td>48 ± 16</td>
<td>57 ± 29</td>
</tr>
<tr>
<td>Postoperative dressing (Bandage: plaster) (per cent)</td>
<td>87.2:12.8</td>
<td>86.2:13.8</td>
<td>28.9:71.1</td>
<td>34:66</td>
</tr>
<tr>
<td>Days in bed (median)</td>
<td>9</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

* See Table III

Table III. Incidence of deep vein thrombosis (DVT) and pulmonary embolism (PE) after elective knee surgery

<table>
<thead>
<tr>
<th>Operation</th>
<th>Total number</th>
<th>Incidence, number and (per cent)</th>
<th>Calf DVT</th>
<th>Proximal DVT</th>
<th>PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total knee arthroplasty</td>
<td>55</td>
<td>31(56.4)</td>
<td>5(9.1)</td>
<td>1(1.8)</td>
<td></td>
</tr>
<tr>
<td>Arthroscopy</td>
<td>48</td>
<td>2(4.2)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Open meniscectomy</td>
<td>151</td>
<td>37(24.5)</td>
<td>3(2)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>58</td>
<td>18(31)</td>
<td>3(5.2)</td>
<td>2(3.4)</td>
<td></td>
</tr>
<tr>
<td>Arthrotomy</td>
<td>45</td>
<td>11(24)</td>
<td>1(2.2)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Arthrodesis</td>
<td>6</td>
<td>4(66.7)</td>
<td>2(33.3)</td>
<td>1(16.7)</td>
<td></td>
</tr>
<tr>
<td>Patellectomy</td>
<td>4</td>
<td>2(50)</td>
<td>0</td>
<td>1(25)</td>
<td></td>
</tr>
<tr>
<td>Synovectomy</td>
<td>3</td>
<td>1(33.3)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
comprised thrombi extending proximally into the popliteal and/or femoral veins (Fig. 2). There were, however, no patients with isolated popliteal or femoral thrombi. Three patients (1%) suffered symptomatic non-fatal pulmonary embolism; all three had major calf thrombi, and two of them also had proximal extension into the popliteal and femoral veins. None of the PEs occurred at the time of the application of an Esmarch bandage (Austin 1963; Pollard, Lovelock and Jones 1983). There were no deaths from pulmonary embolism. Bilateral venograms were performed in 20 consecutive patients; DVTs were detected in five of their operated limbs, and one of these patients had a minor calf thrombosis in the contralateral limb. We observed no significant complications from ascending venography throughout the study.

Table III shows the incidence of DVT in each of the four operative groups. Total knee replacement, arthrodesis and patellectomy all appear to be high-risk procedures with an incidence rate greater than 50%. In contrast, arthroscopy was relatively free from thromboembolic complications. This is partly a reflection of the age differences between the groups, but when comparing the arthroscopy and open meniscectomy groups, whose ages were very similar, the incidence of DVT was 4.2% and 24.5% respectively, which is significantly different (p < 0.01). Although the incidence of DVT after total knee replacement was twice that after meniscectomy, the risk of postoperative DVT in patients over the age of 40 in both groups was similar at 58.5 and 45.2% respectively with no significant difference.

Within each operative group and for the series as a whole, the following pre-operative factors were assessed in relation to both the overall incidence of DVT and that of proximal DVT in particular: age, obesity (weight in kilograms divided by the square of height in metres), history of previous venous thromboembolism, history of trauma or previous surgery to the operated limb, history of varicose veins or venous ulceration, and use of the oral contraceptive pill (Table I). In addition, various operative details were examined: method of exsanguination, duration of surgery, type of postoperative dressing, and duration of postoperative immobility (Table II).

Only the age of the patient and the duration of the operation were significantly different between those patients who developed a DVT and those with normal venograms. For the series as a whole, those patients who developed a DVT were an average 49.1 years of age compared to 34.8 years for those with normal venograms (p < 0.0001). Similarly, operating times were 68.5 and 51.1 minutes respectively (p < 0.0001). However, these differences were attributable to the results from the meniscectomy and miscellaneous groups alone, since there were no significant differences between these two factors in the arthroscopy or the total knee replacement groups. In general, the risk of developing a postoperative DVT increased from about 10% for patients under 30 years of age to almost 50% for patients over 40 years (Fig. 3). Patients with proximal DVTs or PE had a mean age of 60.5 years which is significantly greater than the 48.6 years for those with calf thrombosis alone (p < 0.01). The incidence of thrombi in both sexes was similar. Among those patients undergoing total knee replacement, there was no difference in the risk of DVT between those with rheumatoid arthritis and those with osteoarthritis.

All proximal DVTs were treated by full anticoagulation with heparin followed by Warfarin for three months. Major calf DVTs were generally managed by anticoagulation and minor calf thromboses by elastic compression stockings alone. One meniscectomy patient developed a haemarthrosis in the operated knee following anticoagulation which was therefore discontinued.

**DISCUSSION**

It is well recognised that the diagnosis of deep vein thrombosis is clinically inaccurate; approximately half of those affected have no signs or symptoms referable to the limb and fatal pulmonary embolism may be the first indication of thrombosis (Kakkar and Sasahara 1981). Phlebography remains the gold standard in diagnostic techniques (Whitehouse 1987). Our study of 312 patients undergoing elective knee operations under tourniquet ischaemia has revealed a phlebographically-defined overall incidence of DVT of 28% in patients receiving no specific prophylactic measures.

In common with general surgical and medical patients, but unlike "hip" patients, the more hazardous proximal thrombi were always an extension of a calf
thrombus or arose in conjunction with a discontinuous but simultaneous calf DVT. The incidence of symptomatic pulmonary embolism was 1%, almost certainly a considerable underestimate of the actual incidence (McKenna et al. 1980) but lower than that following hip surgery (Salzman and Harris 1976; Johnson et al. 1977).

Our study confirms the high incidence of DVT following total knee replacement reported by others (McKenna et al. 1976; Lotke et al. 1984). Stulberg et al. (1984) reported a 5% incidence of ipsilateral postoperative DVT, a 7% incidence of PE on perfusion lung scanning and a 17% incidence of clinically diagnosed PE in 517 patients undergoing total knee arthroplasty, figures very similar to ours. However, most of their patients received some form of prophylaxis against venous thromboembolism and the incidence of venous thrombosis was even higher in those patients given no preventative treatment. We agree with their recommendation of routine prophylaxis for patients undergoing total knee replacement surgery. Unlike McKenna et al. (1976) we found no significant difference in the incidence of venous thrombosis between those patients with rheumatoid arthritis and those with osteoarthritis.

Our study has also shown, in a relatively large number of patients, a major incidence of DVT following open meniscectomy, arthroscopy, arthrodesis and patellectomy; this has not been previously reported. This is of importance since these patients were relatively young and in good health apart from their orthopaedic complaint. Arthroscopy appears to be a low-risk procedure, with an overall DVT rate of 4.2% and minimal risk of PE. This agrees with the findings of a national survey carried out by the Arthroscopy Association of North America (DeLee 1985) on almost 120,000 arthroscopies; this revealed a 0.03% incidence (32 patients) of clinically recognised PE of which four were fatal.

Age proved to be a significant risk factor for postoperative thrombosis; patients older than 40 years were particularly vulnerable. This agrees with studies on venous thromboembolism in general surgical patients (Kakkar et al. 1970). Of the many pre-operative and intra-operative variables that we examined in orthopaedic patients, only the patient’s age and, to a lesser extent, the duration of the operation were associated with a significantly higher incidence of postoperative DVT. Furthermore, the mean age of patients with a proximal DVT or a clinically diagnosed PE was even greater.

The pathogenesis of DVT after knee surgery is unknown. The more traumatic procedures, such as total knee replacement appear to carry a particularly high risk. Intra-operative venography to demonstrate the popliteal vein may provide further information, but the absence of isolated popliteal thrombi argues against an analogous situation to that in the femoral vein in total hip replacement (Stamatakis et al. 1977). Postoperative swelling in and around the knee with concomitant venous stasis may well be important. However, since a similar risk exists for patients over 40 years undergoing meniscectomy or total knee replacement (45 and 58%, respectively), other factors must also be significant. Early ambulation was not associated with a significant protective effect in our study and, apart from age, none of the traditional predisposing factors predicted a high-risk group. Pre-operative venography has established that the process is not initiated before operation (Cohen et al. 1973).

In man, systemic fibrinolytic activity is transiently increased after the deflation of a thigh tourniquet; this has led some authors to suggest a possible protective effect of tourniquet ischaemia in relation to postoperative DVT (Fahmy and Patel 1981). In dogs, similar studies have confirmed this but shown a parallel and more prolonged rise in platelet count, fibrinogen levels and haematocrit which could contribute to a hypercoagulable state (Nakahara and Sakahashi 1967). The duration of tourniquet ischaemia was significantly greater in those patients in the meniscectomy and miscellaneous groups who developed a DVT. To study the effect of a thigh tourniquet on the incidence of DVT, Simon et al. (1982) conducted a prospective randomised trial of patients undergoing operations on the foot. They detected no DVTs by 125I-fibrinogen scanning, which was performed only up to 72 hours postoperatively. However, as many as 50% of patients with a DVT show only late rises in radioactive counts, after the third postoperative day (Kakkar 1969). Another study, which was uncontrolled, concluded with little evidence that a tourniquet does not contribute to postoperative DVT (Kroese and Stiris 1976).

We performed ascending venography in a further 15 patients, not included in the main series, who were undergoing surgery to the foot or tibia for Keller’s operation, tibial osteotomy, pes anserinus transfer, hammer toe fusion or excision of cyst. Four DVTs were identified, two major and two minor, all in the calf. Until an adequately controlled randomised trial is performed, the question remains open as to whether a tourniquet, causing venous stasis, ischaemia and possible secondary effects on coagulation, contributes to the development of a DVT. The lack of isolated femoral vein thrombi argues against a local traumatic effect of the cuff.

Our main study indicates that patients over 40 years of age undergoing elective knee surgery other than arthroscopy should receive prophylaxis against venous thromboembolism. This is not only to prevent potentially lethal pulmonary embolism, but also the morbidity associated with deep vein thrombosis and its sequel, the post-phlebitic limb. The lack of any consensus in prophylactic methods is illustrated by the number of subgroups in the Stulberg et al. (1984) analysis of 517 patients undergoing total knee arthroplasty: no prophylaxis, aspirin, low-dose heparin, warfarin, dipyridamole, and non-steroidal anti-inflammatory drugs. Since the patients were not randomised, no firm conclusions could

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be drawn but prophylaxis did appear to lower the incidence of DVT without increasing haemorrhagic complications. Other randomised controlled studies have reported prophylactic benefits in total knee replacement from high-dose aspirin (1.3 g three times daily) but not low-dose aspirin (325 mg three times daily) (McKenna et al. 1980), intermittent calf and thigh compression (McKenna et al. 1980), two-step warfarin therapy (Francis et al. 1983) and pneumatic elastic calf stockings (Hull et al. 1979).

Reportedly unsuccessful prophylactic regimens have included dextran (Francis et al. 1983), and a mechanical continuous-passive-motion device (Lynch et al. 1988). There is urgent need to identify a simple and effective method of prophylaxis; safety is paramount since most thrombi following elective knee surgery are confined to the calf and symptomatic PE only occurs in 1%. Methods needing evaluation include modern pharmacological agents such as low molecular weight heparin (Kakkar and Murray 1985), mechanical compression devices (Gardner and Fox 1988) and combinations of these techniques (Colditz, Tuden and Oster 1986).

**Conclusion.** Postoperative deep vein thrombosis is a common complication not only of total knee arthroplasty but also of a wide variety of other elective knee operations such as meniscectomy, patellectomy, arthroscopy and arthrodesis. Patients over 40 years of age have a particularly high risk and prophylaxis is advisable. Currently there is no consensus on a safe, simple and effective prophylactic regimen and further research is urgently required to reduce the potential morbidity and mortality of venous thromboembolism in these patients.

We are grateful to D. Cooper, PhD, who provided statistical advice, Ms V. P. Ward and Ms R. M. Sanderson of the Clinical Trials section of the Thrombosis Research Unit and Mrs B. M. Radcliffe for typing the manuscript.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

### REFERENCES


