The effect of a thigh tourniquet on the incidence of deep venous thrombosis after operations on the fore part of the foot

MA Simon, DP Mass, CK Zarins, N Bidani, CJ Gudas and CE Metz


This information is current as of August 8, 2007

**Reprints and Permissions**

Click here to [order reprints or request permission](#) to use material from this article, or locate the article citation on [jbjs.org](http://jbjs.org) and click on the [Reprints and Permissions] link.

**Publisher Information**

The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
[www.jbjs.org](http://www.jbjs.org)
The Effect of a Thigh Tourniquet on the Incidence of Deep Venous Thrombosis after Operations on the Fore Part of the Foot

BY MICHAEL A. SIMON, M.D., DANIEL P. MASS, M.D., CHRISTOPHER K. ZARINS, M.D., NALINI BIDANI, M.D., CHARLES J. GUDAS, D.P.M., AND CHARLES E. METZ, PH.D., CHICAGO, ILLINOIS

From the Department of Surgery, Sections of Orthopaedic and Vascular Surgery, and the Department of Radiology, Section of Nuclear Medicine, University of Chicago Hospitals and Clinics, Chicago

ABSTRACT: We performed a prospective randomized clinical study to determine whether use of a thigh tourniquet influences the incidence of deep venous thrombosis. The lower limbs of patients who were scheduled for elective surgery on the fore part of the foot were randomized and assigned to one of three treatment categories: Group I, no tourniquet; Group II, exsanguination by an Esmarch bandage before tourniquet application; and Group III, exsanguination by elevation of the extremity prior to application of a tourniquet. The 117 limbs of seventy-one patients included in this study were evaluated preoperatively and twenty-four and seventy-two hours postoperatively with 125I-labeled fibrinogen, and preoperatively and seventy-two hours postoperatively with Doppler ultrasound studies and phlebophography.

The findings in all of the Doppler ultrasound studies and all of the phlebophograms were normal. Two of the 125I-fibrinogen studies were positive, but subsequent contrast venography revealed that these were false-positive findings. We therefore concluded that the use of a thigh tourniquet does not increase the risk of deep venous thrombosis in patients who have had an operation on the fore part of the foot.

More than a century ago, Virchow first described deep venous thrombosis, which he called embolia. He described the thrombosis as a process that caused venous obstruction and metastatic deposits in the lungs, and he enumerated his famous triad of etiological factors: trauma to the wall of the vein, venous stasis, and hypercoagulability. This triad is still the basis for the treatment and prophylaxis of deep venous thrombosis. When operating on the lower extremity, orthopaedic surgeons routinely use a thigh tourniquet if there are no contraindications and if the operative site lends itself to the use of tourniquet hemostasis. A thigh tourniquet could initiate all three conditions of Virchow's triad: (1) the tourniquet compresses and may injure the deep veins of the thigh; (2) it causes stasis of the blood distal to the site of its application; and (3) the operative procedure may cause hypercoagulability. Therefore, we sought an answer to the question: does use of a thigh tourniquet during elective orthopaedic surgery potentiate the development of deep venous thrombosis? We undertook a prospective randomized clinical study on patients who had elective procedures on the fore part of the foot, with and without the use of a tourniquet.

Methods and Materials

Individuals who had either elective bunionectomy, metatarsal osteotomy, resection arthroplasty, or a soft-tissue procedure in the fore part of the foot between January 1, 1977, and September 30, 1980, were eligible for the study if they were more than eighteen years old, had no history of deep venous thrombosis, had no signs of infection in the limb that was operated on, and did not require a plaster cast for immediate postoperative care. Patients who were pregnant or who were allergic to iodides were excluded. Eligible patients were informed about the nature and risks of the tests, and informed consent was obtained prior to their entry into the study. The lower limbs of the patients were assigned to one of three groups according to a randomization table: Group I, no thigh tourniquet; Group II, exsanguination of the lower extremity by applying an Esmarch bandage before tourniquet application; and Group III, exsanguination by elevation of the extremity before application of a thigh tourniquet. The tourniquet pressure was established at 150 millimeters of mercury more than systolic blood pressure in each patient. If a patient had a bilateral procedure, each extremity was randomized separately.

All patients had a 125I-fibrinogen study, a Doppler ultrasound venous study, and phlebophography of both lower extremities during the twenty-four hours before operation. The 125I-fibrinogen study was repeated at twenty-four and again at seventy-two hours after the operative procedure. The Doppler ultrasound evaluation and phlebophography were repeated seventy-two hours after operation.
postoperatively. If any of these tests indicated deep venous thrombosis, contrast venography was performed according to the protocol, if the venogram confirmed the presence of acute deep venous thrombosis, anticoagulation therapy was to be instituted; however, there were no positive venograms in this series.

**125I-Fibrinogen Study**

For the 125I-fibrinogen study, Ibrin (Amersham Searle) was used. After oral administration of ten drops of Lugol's solution (iodine solution, strong) to block uptake of 125I by the thyroid gland, 100 microcuries of 125I-labeled fibrinogen was injected intravenously. Two hours later, radioactivity was measured over predetermined, marked monitoring positions on the lower extremities. Readings were expressed as percentages of the reading over the heart.

Each limb of every patient was elevated for at least ten minutes prior to counting and each limb was evaluated separately. Preoperative and postoperative counts were performed in identical fashion. A difference of 20 per cent between the counts at adjacent points on the same extremity, or between a point on one extremity and the same point on the opposite extremity, was considered a positive finding. If there was any indication that a thrombus was forming, the study was repeated daily for several days, and a contrast venogram was obtained.

**Phleborheography**

Phleborheography is a modified plethysmographic technique for the detection of deep venous thrombosis. Alterations in intra-abdominal pressure, produced by respiration, influence the venous return and cause phasic fluctuations in the volumes of the lower extremities. Differences in the respiratory fluctuations in limb volume caused by venous thrombosis are measured in this test. Using a Cranley-Grass unit, all patients were evaluated by phleborheography in both the lateral and the supine position. The recordings were made by experienced vascular technicians, and the recordings were interpreted by a vascular surgeon who did not know the group to which each lower limb had been assigned. Loss of normal alterations in limb volume with changes in respiration was considered a positive finding.

**Doppler Ultrasound Venous Study**

Venous flow was evaluated with a five-megahertz, hand-held Doppler ultrasound unit (Medasonics). Venous flow was assessed in the posterior tibial, popliteal, superficial femoral, and common femoral veins of both lower extremities. The results were evaluated by one of two experienced vascular technicians, and abnormalities were verified by a vascular surgeon. None of these individuals had knowledge of the study group to which each lower limb belonged. Abnormal features — including absence of respiratory fluctuation, absence of augmentation, reflux, high-pitched collateral flow signals, and absent flow signals — were considered positive findings.

---

**TABLE I**

<table>
<thead>
<tr>
<th>No. of Limbs</th>
<th>Mean Age* (Yrs.)</th>
<th>Sex (No.)</th>
<th>Mean Tourniquet Time* (Mins.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>42</td>
<td>34 F</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>45.6 ± 13.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(26-76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group II</td>
<td>40</td>
<td>36 F</td>
<td>82.5 ± 31.9</td>
</tr>
<tr>
<td></td>
<td>48.3 ± 14.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24-76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group III</td>
<td>35</td>
<td>29 F</td>
<td>73.7 ± 30.4</td>
</tr>
<tr>
<td></td>
<td>47.2 ± 10.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(25-64)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Means and standard deviations. Numbers in parentheses are ranges.

**Results**

The 165 limbs that were operated on in 101 patients were randomized: fifty-five in Group I, sixty in Group II, and fifty in Group III. There were forty-eight violations of the protocol for technical or administrative reasons, so that forty-eight lower limbs did not have all of the examinations at the appropriate times: thirteen in Group I, twenty in Group II, and fifteen in Group III. Excluding these, there were 117 limbs that were evaluated properly in seventy-one patients (fifty-nine women and twelve men): forty-two lower limbs in Group I, forty in Group II, and thirty-five in Group III. The age and sex of the patients and the tourniquet time were comparable for the three groups (Table I). About two-thirds of the patients studied were between thirty-five and sixty-five years old. The tourniquet times for the patients in Group II ranged from twenty-seven to 184 minutes (average, 82.5 minutes) and in Group III, from thirty-two to 168 minutes (average, 73.7 minutes).

The primary diagnosis for each of the 117 limbs that were evaluated fully is shown in Table II. The primary diagnoses in each of the three groups were quite similar. The preponderant diagnosis in all three groups was hallux valgus. Only five patients had rheumatoid arthritis: four in Group I and one in Group III. These five patients were taking medications that had an antithrombotic effect. The major operative procedures performed on the 117 limbs are shown in Table III. The distribution of the different types of operations in the three groups was similar. The vast majority of patients had either a first metatarsal osteotomy or a

---

**TABLE II**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hallux valgus</td>
<td>30</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>Hallux rigidus</td>
<td>1</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Plantar-flexed</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Metatarsal head</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Hammer toes</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Neuroma</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Vol. 64-A, No. 2, February 1982
TABLE III
SURGICAL PROCEDURES ON ONE HUNDRED AND SEVENTEEN FULLY EVALUATED LIMBS

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>First metatarsal osteotomy</td>
<td>15</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Soft-tissue bunion procedure with or without Silastic implant</td>
<td>18</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Lesser metatarsal osteotomy</td>
<td>8</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Hammer-toe arthroplasty</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Soft-tissue procedure</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

soft-tissue bunion procedure, with or without a Silastic implant.

The postoperative regimen and time to mobilization for the major types of operative procedures were controlled rigidly and were similar for the limbs in all three groups. Following a metatarsal osteotomy, the patient was kept on bed rest for three days. On the third postoperative day, a below-the-knee walking cast was applied after the non-invasive venous tests were performed. The patient was discharged the following day, with instructions to walk with weight-bearing as tolerated. Two weeks after discharge the cast was removed, the sutures were taken out, a radiograph of the foot was made, and a new below-the-knee cast was applied. Four weeks after discharge the cast was removed permanently. The patient then was seen on a routine basis for five more months. Following a soft-tissue bunion procedure with or without a Silastic implant, a hammer-toe arthroplasty, or a soft-tissue procedure, the patient was kept on bed rest for only one day and then was encouraged to walk ad libitum. On the third postoperative day, after the non-invasive venous tests were completed, each patient was discharged and was allowed weight-bearing as tolerated, without a cast. Thereafter the follow-up was similar to that for patients with a metatarsal osteotomy.

In all limbs, the results of the preoperative phleboreograms, Doppler ultrasound examinations, and 125I-fibrinogen studies were normal. Postoperatively, all phleboreograms and Doppler ultrasound examinations gave normal results at seventy-two hours. In two lower extremities the 125I-fibrinogen studies were abnormal: one in Group I and the other in Group II. Subsequent contrast venograms, however, showed that both limbs were normal. The findings in the forty-eight randomized limbs that were excluded because of protocol violations also were normal in all of the studies that were performed, except for one abnormal 125I-fibrinogen study on a limb in which a subsequent contrast venogram gave normal results. Thus, the limbs of the patients who were eliminated from the study because of protocol violations did not differ from those in the study groups.

Obviously, because no deep venous thrombosis was found in any limb in the three groups, no statistically significant differences between the probability of thrombosis in the limbs in the various groups could be demonstrated. However, in order to infer from the data the ranges within which the probabilities of thrombosis appear to be, for each group we calculated the upper limit on a hypothesized probability of thrombosis which, if tested against the observation of no thrombosis in any limb in that group, would be accepted at the 95 per cent confidence level. Thus, if P represents a hypothesized probability of thrombosis in a single limb, then the probability of finding no thrombosis in N independently selected limbs is \((1 - P)^N\). At the 95 per cent confidence level, the hypothesized value of P is consistent with the observation of no thrombosis in any of the N limbs if \((1 - P)^N\) is greater than 0.05 or, equivalently, if P is less than 1 - (0.05)^\(1/N\).

Using this approach, we found that at the 95 per cent confidence level the probability of deep-vein thrombosis developing was less than 6.9 per cent in Group I, less than 7.2 per cent in Group II, and less than 8.2 per cent in Group III. When the data from Group II and Group III were pooled, the probability of deep-vein thrombosis developing after the use of a tourniquet was less than 3.9 per cent at the 95 per cent confidence level. We emphasize that the differences between the probability ranges quoted here do not suggest any apparent differences between the probability of thrombosis in the limbs of the various groups or the pooled group, but merely reflect the different numbers of lower extremities included in the three groups and in the pooled group in this study.

Discussion

We chose to use elective surgery on the fore part of the foot as the clinical model for our study of venous thrombosis for two reasons. First, these procedures cause no operative damage to the deep venous system, thus enabling us to treat the application of a tourniquet on the thigh as an independent variable. In operations elsewhere in the lower extremity, the operative trauma contributes to the development of deep venous thrombosis 4,14,17. Second, since the operative trauma was limited to the fore part of the foot, we were able to use 125I-fibrinogen studies to detect deep venous thrombosis without concern for the false-positive interpretations that often accompany trauma 3,5,6,8,10,15.

Even when clinical signs or symptoms of thrombosis are present, the accuracy of the clinical diagnosis of deep venous thrombosis is only 50 per cent 5,6,17. The most accurate test is contrast venography, but it is invasive and entails some risk 8,16,20. Therefore, we chose the three non-invasive examinations used in this study to detect deep venous thrombosis. All can be performed at the bedside with little risk to the patient. The 125I-fibrinogen study is a highly sensitive test for the presence of forming thrombi. However, it may not detect thrombi in the proximal third of the thigh because of the attenuation of radioactivity by the large muscle mass and the high background counts. This study also gives false-positive results in any area that has been subjected to recent trauma, surgical or otherwise. The test is most valuable in the detection of thrombi in the calf. The diagnostic accuracy (true-positive and true-negative results) of 125I-fibrinogen studies has been re-
Phleborheography and Doppler ultrasound studies are sensitive methods for detecting thrombi in the thigh, but they are less sensitive in the smaller tributary vessels of the calf. When phleborheography or impedance plethysmography and Doppler ultrasound are used together, the combined rate of error (false-positive and false-negative results) has been reported to be about 5 per cent. Although tests made more than seventy-two hours after operation might have given more accurate results, we chose a seventy-two-hour observation period for several reasons. Because all patients were fully ambulatory at seventy-two hours, it seemed that the risk for late development of deep venous thrombosis would be minimum. Since almost all patients were ready for discharge at this time, it would have been inconvenient and costly to continue the studies. While the peak incidence of clinically evident deep venous thrombosis occurs between one and two weeks, previous studies employing labeled fibrinogen have shown that the vast majority of thrombi are initiated within forty-eight hours after operation. It is possible that at seventy-two hours phleborheography and Doppler ultrasound may not detect small thrombi, but these should be detected by labeled fibrinogen. In support of our decision to use an observation period of seventy-two hours, no patient in the study (101 patients) had clinically detectable deep venous thrombosis or pulmonary embolus during the entire postoperative and follow-up observation period.

Our study shows that the incidence of deep venous thrombosis after elective operations on the fore part of the foot is much lower than the incidence after elective operations on the hip or knee. This difference may be related to the location of the operative site and to the earlier postoperative mobilization of the limb after surgical procedures on the fore part of the foot. Operations on the hip and knee cause direct trauma to local deep veins or extrinsic compression of the deep veins of the lower extremity. Also, after these procedures the limb is mobilized relatively slowly. Elective operations on the fore part of the foot cause no trauma to the deep venous system, and postoperatively the limb is mobilized quickly. The findings in this study are consistent with these concepts, and prophylactic anticoagulation is not indicated for elective surgical procedures on the fore part of the foot.

The use of a tourniquet during operation has the advantage that it makes the operative site bloodless and enables the surgeon to visualize structures clearly and therefore to operate quickly, with little blood loss. It is well known that, if a tourniquet is inflated too long or at too high a pressure, nerve palsies, skin necrosis, or irreversible ischemic changes may occur. However, the relationship between the use of a tourniquet and occurrence of deep venous thrombosis has never been established. In our series, application of a thigh tourniquet during operations on the fore part of the foot did not enhance the development of deep venous thrombosis. However, these data apply only to limbs that are exsanguinated either by application of an Esmarch bandage or by elevation of the limb; they also cannot be extended to surgical sites in the thigh, knee, or calf.

References