Asymmetry of the Calves in the Assessment of Patients With Suspected Acute Pulmonary Embolism

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Purpose: The purpose of this investigation was to evaluate measured asymmetry of the calves in the assessment of patients with suspected pulmonary embolism (PE).

Methods: Patients randomized for pulmonary angiography in the collaborative study of the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) were evaluated. Only patients in whom the circumference of the calves was measured were included in this evaluation of PIOPED data. Among these, 232 had angiographically diagnosed PE and 446 had no PE by angiography. For purposes of comparison, measurements of the calves were made in a nonrandomized current cohort of 101 healthy subjects. All calf measurements were made 10 cm below the tibial tuberosity.

Results: Asymmetry in the circumference of the calves of 1 cm or more was measured in 101 of 232 or 44% (95% confidence interval CI, 37 to 51%) with PE, 176 of 446 or 39% (95% CI, 34 to 44%) without PE, and in 6 of 101 or 6% (95% CI, 1 to 11%) control subjects (PE vs control subjects, p<0.001; PE vs no PE, p=NS). Among patients with PE, the addition of calf asymmetry of 1 cm or more to qualitative signs of deep venous thrombosis increased the prevalence of a detectable abnormality of the lower extremities from 62 of 232 or 27% (95% CI, 21 to 33%) to 129 of 232 or 56% (95% CI, 49 to 63%, p<0.001).

Conclusion: Asymmetry of the calves of 1 cm or more is abnormal. Such asymmetry of the calves did not distinguish between patients with PE and those with no PE. When considered in proper perspective with other non-specific signs and symptoms in patients with suspected acute PE, however, subtle calf asymmetry may call attention to the possibility of thromboembolic disease. The observation of subtle asymmetry may indicate a need for noninvasive diagnost: tests of the lower extremities to determine whether deep venous thrombosis is present.

CI=confidence interval; PE=pulmonary embolism; PIOPED=prospective investigation of pulmonary embolism diagnosis

Key words: clinical diagnosis; deep venous thrombosis; noninvasive tests; pulmonary embolism; thromboembolism

Emphasis, in recent years, has been placed on the diagnosis and treatment of deep venous thrombosis in patients with suspected acute pulmonary embolism (PE).1-5 Although thromboemboli originate in the veins of the lower extremities in 80% or more of patients with PE,6-9 the signs of deep venous thrombosis on physical examination were present only in 33% of patients who had massive or submassive PE by pulmonary angiography.10 Signs of deep venous thrombosis were present in 37% of patients who showed PE at autopsy, the majority of which caused or contributed to death.11 In patients with mild as well as severe PE, who had no prior cardio-pulmonary disease, signs of deep venous thrombosis were present in only 11%.12 The investigators in these studies evaluated symptoms and qualitative signs including edema, erythema, tenderness, palpable cord, and Homan's sign. Measurements of the calves were not reported.10-12 The purpose of the present investigation is to evaluate measurements of the calves in patients with acute PE to determine if subtle differences in the circumferences of the calves may identify patients with suspected PE in whom further tests may be indicated.

Methods

Patients With Pulmonary Embolism Diagnosed or Excluded by Pulmonary Angiography

Patients in this study participated in the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED).13 The eligible population consisted of patients who were 18 years of age or more in whom acute PE was of diagnostic concern. In the present evaluation of data from PIOPED, only patients in the arm of the study who consented to obligatory pulmonary angiography were included.15 Physical examinations were performed within 24 h prior to angiography. A complete physical examination of the legs, including measurements of the calves, was made in 232 patients with PE shown by pulmonary angiography and in 446 patients in whom PE was excluded by pulmonary angiography. Examination of the legs included an evaluation of the presence or absence of edema, erythema, tenderness, palpable cord, and

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Homan's sign. We define these as qualitative signs. In all patients, the circumference of the calves was measured 10 cm below the tibial tuberosity. The age of patients with PE vs those without was 59 ± 16 years vs 57 ± 17 years (p=0.06).

Subjects With No Suspected Thromboembolic Disease

A nonrandomized current cohort of healthy subjects served as normal control subjects. Evaluation of the legs, including measurement of the calves 10 cm below the tibial tuberosity, was made in 101 men and women with no suspected thromboembolic disease. Control subjects were in good general health; 97 were hospital employees, and 4 were patients in the otorhinolaryngology clinic. Subjects were excluded if they had a history of thrombophlebitis, leg pain, swelling of the legs, fracture of a lower extremity, orthopedic surgery involving the lower extremities, or heart failure. Control subjects were 39 ± 12 years of age.

Statistical Methods

A χ² test with Yates correction was used to compare the prevalence and distribution of clinical signs of deep venous thrombosis. The 95% confidence interval (CI) was calculated according to Galen and Gambino. Comparisons of continuous variable means were made with Student’s t test. Data are reported as mean ± SD.

RESULTS

The prevalence of various magnitudes of differences of the circumference of the calves did not differ between patients with PE vs those with no PE (Table 1). Differences in circumference of the calves of 1 cm or more were observed in 101 of 232 (44% [95% CI, 37 to 51%]) with PE and 176 of 446 (39% [95% CI, 34 to 44%]) without PE (p=NS) (Table 1). Both patients with and without PE had asymmetry of the circumference of the calves of 1 cm or greater more frequently than control subjects (6 of 101 [6%], 95% CI, 1 to 11%). The probability value is less than 0.001.

The association of qualitative signs (edema, erythema, tenderness, palpable cord, or Homan’s sign) with measured differences of calf circumference of 1 cm or more is shown in Table 2. Among patients with PE, 62 of 232 (27% [95% CI, 21 to 33%]) had 1 or more qualitative signs of deep venous thrombosis and an additional 67 of 232 (29% [95% CI, 23 to 35%]) had a 1 cm or more difference of calf circumference, which was not accompanied by any qualitative signs. The addition of a measured difference of calf circumference of 1 cm or more, therefore, increased the prevalence of detectable abnormalities of the lower extremities from 62 of 232 (27% [95% CI, 21 to 33%]) to 129 of 232 (56% [95% CI, 49 to 63%]), with a probability value of less than 0.001 (Table 2). Similarly, among patients who did not have PE, the inclusion of a measured difference of calf circumference of 1 cm or more increased the prevalence of detected abnormalities of the lower extremities from 96 of 446 (22% [95% CI, 18 to 26%]) to 219 of 446 (49% [95% CI, 44 to 54%]), with a

Table 1—Differences of Circumference of Calves

<table>
<thead>
<tr>
<th></th>
<th>0 to 0.9 cm</th>
<th>1.0 to 1.5 cm</th>
<th>1.6 to 2.0 cm</th>
<th>≥2.1 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Patients</td>
<td>%</td>
<td>No. Patients</td>
<td>%</td>
</tr>
<tr>
<td>Pulmonary embolism (n=232)</td>
<td>131</td>
<td>57*</td>
<td>63</td>
<td>27*</td>
</tr>
<tr>
<td>No pulmonary embolism (n=446)</td>
<td>270</td>
<td>61*</td>
<td>120</td>
<td>27*</td>
</tr>
<tr>
<td>Control subjects (n=101)</td>
<td>95</td>
<td>95</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Differences between patients with PE vs patients without were not statistically significantly different. Differences among patients with PE vs control subjects and differences among patients without PE vs control subjects were as follows:

*p<0.001;
†p<0.02;
‡p<0.01;
§p<0.05.

<table>
<thead>
<tr>
<th></th>
<th>&lt;1 cm Difference and No Signs</th>
<th>&lt;1 cm Difference and Any Signs</th>
<th>≥1 cm Difference and No Signs</th>
<th>≥1 cm Difference and Any Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Patients</td>
<td>%</td>
<td>No. Patients</td>
<td>%</td>
</tr>
<tr>
<td>PE (n=232)</td>
<td>109</td>
<td>44</td>
<td>28</td>
<td>12</td>
</tr>
<tr>
<td>Without PE (n=446)</td>
<td>227</td>
<td>51</td>
<td>43</td>
<td>10</td>
</tr>
</tbody>
</table>

*Signs of deep venous thrombosis include tenderness, edema, erythema, calf tenderness, and Homan’s sign, and if associated with differences of calf circumference, were on the same side as the larger calf. All differences between patients with PE and without were not statistically significant.
probability value of less than 0.001 (Table 2).

**Discussion**

Assessment of the lower extremities in patients with suspected PE usually has been on the basis of qualitative signs including edema, erythema, tenderness, palpable cord, and Homan's sign. On this basis, only 11 to 37% of patients with PE had abnormalities of the lower extremities suggestive of deep venous thrombosis. Among patients with deep venous thrombosis, these qualitative signs were observed more frequently, 49 to 95%, although they were not specific.

Swelling of the calf, if the thigh measurements are equal, implies at least obstruction of the femoral or popliteal vein. Among the few investigators who reported measured differences of the circumference of the calves, asymmetry in the circumference of the calf of 1 cm or more was shown in 90% of patients with proven deep venous thrombosis, but such swelling also was shown in 92% of patients with suspected deep venous thrombosis in whom the diagnosis was excluded which indicates that most patients referred for studies of the lower extremities had calf asymmetry. Others showed that asymmetry of the calves of less than 3 cm was not specific for deep venous thrombosis. A measured difference of the circumference of the calves of greater than 2 cm was shown in approximately 3% of patients with deep venous thrombosis, but specificity was not reported. A difference of 3 cm or more was associated with a high likelihood of having deep venous thrombosis. We have been unable to find reported values of calf measurements in healthy subjects. Measurements in control subjects in our investigation indicate that a difference of circumference of the calves of 1 cm or more is abnormal.

Among patients with PE, the addition of a measured asymmetry of calf circumference of 1 cm or more to the qualitative signs (tenderness, palpable cord, edema, erythema, Homan's sign) added prominently to the detectable abnormalities of the lower extremities, which are suggestive of deep venous thrombosis. In PIOPED, evaluation of the lower extremities by impedance plethysmography, ultrasound, or venogram was not part of the protocol. The prevalence of deep venous thrombosis, therefore, among patients in PIOPED in whom PE was diagnosed or excluded is not known. Autopsy investigations, however, indicate that deep venous thrombosis is present in 80% or more of patients with PE.

In conclusion, although asymmetry of the circumference of the calves of 1 cm or more has been reported to be nonspecific for the diagnosis of deep venous thrombosis, such asymmetry is clearly abnormal. Such asymmetry of the calves did not distinguish between patients with PE and patients without it. When considered in proper perspective with the other nonspecific signs and symptoms of PE, a measured difference of calf circumference of 1 cm or more increases the prevalence of detectable abnormalities in patients with suspected acute PE. Subtle asymmetry of the calves may indicate a need for noninvasive diagnostic tests of the lower extremities to determine whether deep venous thrombosis is present.

**References**