**Anatomical Relationship between Saphenous Vein and Cutaneous Nerves**

By

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**Summary:** The anatomical relationship between the saphenous veins and cutaneous nerves was investigated in 148 lower limbs of 74 cadavers in order to re-examine the stripping technique for treatment of varicose veins. The great saphenous vein frequently ran intimately along the saphenous nerve (59.5% in the middle third and 83.1% in the lower third of the leg) in the leg region. More than half of the latter cases showed an adhesive relationship in which the perineurium of the saphenous nerve was seen histologically to be attached to the adventitia of the vein. Moreover, in the thigh region as well, the great saphenous vein had an intimate relationship with the cutaneous nerves of various origin. In contrast, the small saphenous vein was often located close to the cutaneous nerves of the calf like the sural nerve. However, the adhesive relation between the small saphenous vein and nerves was rarely observed, in contrast to the case of the great saphenous vein.

From these results, the anatomical relationship between the superficial vein and nerve in the lower limb were characterized according to each part of the lower limb. Based on our observations, limited extraction of the vein was recommended to reduce the risk of nerve injury during the stripping operation.

Stripping of the saphenous vein is the most common surgical procedure for varicose veins. During the operation, the great or small saphenous vein, often along its entire course, is removed from the subcutaneous tissue. However, postoperative cutaneous nerve damage has been pointed out (Lajos and Espersen, 1983; Cox, 1974), so that the procedure has been modified for use only in the limited area in which cutaneous nerves seem to be at a distance from the vein (Holme et al., 1990; Sarin et al., 1992). Although an intimate relationship between the saphenous veins and cutaneous nerves is described in anatomy textbooks (Clemente, 1985; Williams and Warwick, 1980), few statistical studies on the relationship have been performed specifically in the leg region of Caucasians (Holme et al., 1988). Moreover, significant variations have been demonstrated in the course of the saphenous vein of Caucasians (Hollinshead, 1969; McVay, 1984) and the Japanese (Morita et al., 1966) as well as in that of cutaneous nerves in the lower limbs of Japanese (Tani, 1974; Takeuchi et al., 1977). Banjo (1987) suggested the existence of differences in variation of the vein among the various human races. Since the stripping operation has been performed for more than 30 years in Japan without any evaluation based on sufficient anatomical data, we conducted this study to clarify the anatomical relations between the superficial vein and nerve in Japanese in order to re-examine the stripping technique.

**Materials and Methods**

One hundred and forty-eight lower limbs from 74 cadavers (60 males and 14 females), aged 27–94 years, without varicose veins, were dissected after fixation by perfusion of 7–10% formol solution in water.

Observations were made in each third of the thigh or the leg. The thigh region, from the level of the saphenofemoral junction to that of the top of the patella, was divided into three parts, the upper, middle and lower. The leg region, from the level of the knee joint to the lateral or medial malleolus, was also divided into three parts.

Although the tributaries and courses of the saphenous veins showed many variations, such as
the accessory saphenous vein (Hollinshead, 1969; McVay, 1984), it was not difficult to discriminate the main trunk of the vein from its collateral veins. The main trunk of the great saphenous vein was defined as the longest and largest vein showing a straight course from the medial malleolus to the sapheno-femoral junction. In addition, the small saphenous vein was defined as that running along the mid-line of the calf from the lateral malleolus to the popliteal fossa.

During macroscopic observations, an intimate relationship between the vein and the nerve was often observed and the relationship could be divided into two types: “close” and “adhesive” relations. In both types, the vein ran close the nerve with a distance of about 1 mm distance between them. However, in the adhesive relation cases, the vein could not be separated from the nerve with forceps, but required a scalpel. In order to confirm the morphological difference in the intimate relations, histological examinations were performed during or after the gross observations. Forty specimens of the great saphenous vein and 20 specimens of the small saphenous vein that exhibited an intimate relation with nerves, were removed with the nerves from the intact site in which the specimens had not been damaged during the gross examinations. Cross sections were made and stained with hematoxylin and eosin following the routine procedure for paraffin sections (Plate 1).

In addition, during or before the above observations, in 30 of the total of 148 lower limbs examined, skin with subcutaneous tissue of the entire length of the medial half of the limb was detached from the deep fascia. The specimens of the skin were used for the whole-mount silver impregnation method for cutaneous nerves (Kimura and Takahashi, 1985) to serve for the observation of fine nerve twigs and nerve distribution along the vein (Plate 2). The specimens were fixed again with PBS-buffered 10% formol solution (pH 7.2), rinsed in tap water and immersed in a 0.7% solution of silver nitrate (Kanto-kagaku) in the dark for silver impregnation.

Results

An intimate relation in gross observations between the vein and nerve, described as either the adhesive or close relation, usually corresponded to a characteristic histological finding (Plate 1). In the adhesive relation, the vein and nerve were enclosed by a common thick sheath and thick bundles of collagen fibers connected the adventitia of the vein to the perineurium of the nerve. In contrast, in the close relation, the nerve was also located rather intimately along the vein within a distance of about 1 mm, but the loose connective tissue partly separated the perineurium from the adventitia.

1. Thigh region (Table 1)

The relationships between the great saphenous vein and cutaneous nerves in the thigh region were characterized as of a wide variety at the origin of the nerves. Moreover, the nerve was located close to the vein in a limited site, and not along the long course of the vein in the thigh region. However, the adhesive relation was rarely observed (3 of the 148 legs) in the thigh region.

The anterior cutaneous branch of the femoral nerve ran intimately along the great saphenous vein in 63 of the 148 legs (42.6%). Most frequently (55 of the 63 cases, 87.3%), the nerve branch showed the close relation with the vein along 5–10 cm of its course. The close relation was observed in the upper third of the thigh region (22 cases) and also in the middle third (23 cases, Plate 3) or in the lower third (10 cases) of the thigh region. After piercing the fascia lata at the level of the saphenofemoral junction, the nerve branch ran distally and medially. It innervated the skin in the medial and lower half of the thigh. However, when the nerve branch perforated the sartorius muscle and then approached the vein (5 cases), it pierced the fascia lata at the middle level of the thigh and ran closely along the vein over a longer course (10–15 cm) from the middle third to

<table>
<thead>
<tr>
<th>region/nerve</th>
<th>ant. cut.</th>
<th>obt.</th>
<th>saph.</th>
<th>lat. cut.</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
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<td>24</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>close</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>adhesive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(16.9%)</td>
</tr>
<tr>
<td>middle 1/3</td>
<td>30(6)</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>close</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>adhesive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(22.7%)</td>
</tr>
<tr>
<td>lower 1/3</td>
<td>15(5)</td>
<td>6</td>
<td>10</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>close</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>adhesive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(22.3%)</td>
</tr>
</tbody>
</table>

1. Anterior cutaneous branch of the femoral nerve
2. Cutaneous branch of the obturator nerve, including the communication branch to the femoral nerve
3. Branch of the saphenous nerve
4. Lateral femoral cutaneous nerve
5. Criteria of <close> and <adhesive> are described in the Materials and Methods section.
6. Total numbers of close and adhesive cases in the region. Percentage in the total of 148 cases examined from 74 cadavers.
7. In 6 or 5 cases of the total <close> cases in these regions, the anterior cutaneous branch ran along the vein after perforating the sartorius muscle.
the lower third of the thigh. The long course which was close to the vein was in contrast to the short course observed in the cases without perforation of the muscle.

The cutaneous branch of the obturator nerve sometimes (12 cases, 8.1%) ran intimately along the great saphenous vein in the middle or the lower third of the thigh region. The nerve branch joined the cutaneous branch of the femoral nerve. In addition, the nerve branch, which arose from the saphenous nerve in the adductor canal, also sometimes ran intimately along the vein in the middle or lower third of the region (15 cases, 10.1%).

2. Leg region
   A. The great saphenous vein (Table 2, Plate 2)

   The intimate relation between the great saphenous vein and the main trunk of the saphenous nerve was observed in 123 cases (83.1%). The nerve trunk consistently became progressively more intimately related to the vein as it descended to the medial malleolus. As a result, the adhesive relation was more frequently found in the lower parts of the leg. In the 123 cases with the intimate relation, most frequently (92 in 123 cases, 74.8%), the saphenous nerve pierced the crural fascia in the upper third of the leg region, and also the nerve often (31 cases, 25.2%) pierced the fascia at a higher level just below the patella. In the latter cases, in which the nerve emerged into the subcutaneous tissue at a higher level, the nerve approached the vein immediately after piercing the fascia. This immediate approach resulted in a high incidence of the adhesive relation in the upper and middle third of the leg. In contrast, in 35 of 92 cases in which the nerve pierced the fascia in the upper third of the leg, the nerve paralleled the vein during its long course and finally exhibited the close relation with the vein in the lower third of the leg.

   Even in cases with the intimate relation, the saphenous nerve was often (49 of the 123 intimate relation cases) composed of several nerve bundles, each of which was clearly separated by the perineurium (Plates 1 and 2).

   B. The small saphenous vein (Table 3, Plate 3)

   The cutaneous nerve of the calf pierced the crural fascia in the upper half of the calf and showed a long course in the subcutaneous tissue. As a result, the intimate relations between the small saphenous vein and cutaneous nerves were frequently observed (110 of 148 legs, 74.3%). However, in the 110 intimate relation cases, the adhesive relation observed was limited to only 5 cases. In the lower third of the calf, the close relation was seen in 70.9% in contrast to the low incidence (3.4%) of the adhesive relation. The cutaneous nerve usually did not show a more intimate relation with the small saphenous vein as it descended to the lateral malleolus. The nerve tended to maintain a parallel course along the vein. Moreover, in 38 of a total of 148 legs examined, in which the nerve did not exhibit the intimate relation, the nerve maintained its parallel course at a distance of

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Table 2. Relations of the great saphenous vein and the saphenous nerve in the calf region.

<table>
<thead>
<tr>
<th>region/nerve</th>
<th>saph.</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper 1/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>close</td>
<td>28 (18.9%)</td>
<td>31</td>
</tr>
<tr>
<td>adhesion</td>
<td>3 (2.0%)</td>
<td>(20.9%)</td>
</tr>
<tr>
<td>middle 1/3</td>
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</tr>
<tr>
<td>close</td>
<td>74 (50.0%)</td>
<td>88</td>
</tr>
<tr>
<td>adhesive</td>
<td>14 (9.5%)</td>
<td>(59.5%)</td>
</tr>
<tr>
<td>lower 1/3</td>
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<td></td>
</tr>
<tr>
<td>close</td>
<td>45 (30.4%)</td>
<td>123</td>
</tr>
<tr>
<td>adhesive</td>
<td>78 (52.7%)</td>
<td>(83.1%)</td>
</tr>
</tbody>
</table>

1. Main trunk of the saphenous nerve in the calf region
2. Criteria of <close> and <adhesive> are described in the Materials and Methods section.
3. Percentage in the total of 148 cases examined.
4. Total numbers of close and adhesive cases in the region. Percentage in the total of 148 cases examined.

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Table 3. Relations of the small saphenous vein and cutaneous nerves of the calf.

<table>
<thead>
<tr>
<th>region/nerve</th>
<th>P</th>
<th>P’</th>
<th>P + T</th>
<th>T’</th>
<th>T</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper 1/3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>close</td>
<td>0</td>
<td>2</td>
<td>16</td>
<td>2</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>adhesive</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>(16.9%)</td>
</tr>
<tr>
<td>middle 1/3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>close</td>
<td>1</td>
<td>10</td>
<td>24</td>
<td>13</td>
<td>3</td>
<td>51</td>
</tr>
<tr>
<td>adhesive</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>(34.5%)</td>
</tr>
<tr>
<td>lower 1/3</td>
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<td></td>
<td></td>
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<tr>
<td>close</td>
<td>10</td>
<td>34</td>
<td>35</td>
<td>24</td>
<td>7</td>
<td>110</td>
</tr>
<tr>
<td>adhesive</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>(74.3%)</td>
</tr>
</tbody>
</table>

1. Classification of the origin of the cutaneous nerves. P: only from the common peroneal nerve (P), (8.1%). P’: mainly from P and partly from the tibial nerve (T), (33.8%). P + T: typical sural nerve, equally from P and T (20.9%). T’: mainly from T and partly from P (31.1%). T: only from T (6.1%). (%): incidence in the total of 148 cases.
2. Criteria of <close> and <adhesive> are described in the Materials and Methods section.
3. Total numbers of close and adhesive cases in the region. Percentage in the total of 148 cases examined.
about 1 cm from the vein in the calf region.

The cutaneous nerve of the calf, which ran closely along the small saphenous vein, varied significantly in origin. Based on the nerve origin, the accompanying nerves were divided into 5 types as shown in Table 3. The typical sural nerve, Type P + T in Table 3, pierced the crural fascia in the upper or middle third of the calf, then approached the vein to show the close relation in the lower third of the calf. In this type, the incidence of the close relation (37 cases, 25.0%) was higher than that expected from the incidence of the nerve type (20.9%).

These results are summarized in Plate 4. There appeared to be no difference in findings between sexes nor among variations in body weight, height and shape.

Discussion

From these observations, the relations between the superficial vein and nerve were characterized according to each part of the lower limb. The site of the adhesive relation tended to be limited to the middle and lower third of the leg region. However, a close relation was observed along the entire course of the great and small saphenous veins. In the thigh region, the appearance of the intimate relations depended on the origin and course of the nerve branch (Plate 4). In particular, we noted that the anterior cutaneous branch of the femoral nerve possibly accompanied the vein at the level near the saphenofemoral junction, since varicose veins often occur at the terminal portion of the vein as well as that along the leg. A branch of the saphenous nerve was also noted in the thigh region, due to a low level of the adhesive relation with the vein. In the leg region, the cutaneous nerve of the calf rarely adhered to the small saphenous vein, in spite of the high incidence of the close relation. This finding contrasted clearly with the relations between the great saphenous vein and the saphenous nerve in the leg. The saphenous nerve became progressively more close related to the vein as it descended, resulting in the nerve adhering to the vein in the lower part of the leg. It is still unclear whether the relation varies among different human races.

Myers et al. (1991) demonstrated that epineurial devascularization of the rat sciatic nerve caused ischemia of nerve fibers resulting in subperineurial demyelination. They concluded that extrinsic as well as intrinsic circulation is important for the blood supply to peripheral nerves. We demonstrated that the perineurium of the cutaneous nerve was attached to the adventitia of the superficial vein in cases with adhesive relations. In these cases, the vein, nerve and also fine vessels, which seemed to take a common blood supply to the vein and nerve, were enclosed together by a common sheath. Therefore, we suggest that nerve injury after a stripping operation seems to be caused not only by mechanical damage during the procedure of separating the vein from the nerve, but also by damage to the perineurial connective tissue in which fine vasa nervorum exist.

From these anatomical considerations, limited extraction of the varicose vein is mostly recommended for the great saphenous vein in any region of the lower limb. Even if longer extraction is necessary for the great saphenous vein along the leg region, the stripped area should be limited to the upper half of the region.

Acknowledgement

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References

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Explanation of Figures

Plate I

Histological demonstrations of the intimate relation between saphenous veins and cutaneous nerves. The open arrow indicates the superficial side.

A. In adhesive relation cases, the superficial vein (V) and the accompanying nerve (N) are enclosed by a well-developed common sheath (arrows). The perineurium (open stars) is closely attached to the adventitia (black stars). Several fine vessels (arrowheads) are located between the vein and the nerve. Thick bundles of collagen fibers (white asterisks) connect the adventitia to the perineurium. These result in difficulty in separating the vein from the nerve without a scalpel. Sampled from the great saphenous vein and saphenous nerve in the leg. Scale: 1 mm.

B. In close cases, the nerve (N) is also located within a distance of about 1 mm from the vein (V). The perineurium (open stars) is connected to the adventitia (black stars) by relatively thin bundles of collagen fibers (arrows). Several fine vessels (arrowheads) are located between the vein and the nerve. However, the loose connective tissue (black asterisks) partly separates the perineurium from the adventitia. Sampled from the small saphenous vein and the sural nerve. Scale: 1 mm.
Plate II

Photographs showing the adhesive relation of the great saphenous vein and the saphenous nerve in the middle third of the leg. Silver-impregnated specimens of the skin after clearing in methylsalicylate. Nerve bundles and branches are clearly observed. Viewed from the inner side of the right leg. The open arrow indicates the medial side. The saphenous nerve (N, large arrowheads) divides into several nerve bundles at the lower part of the figure. In the silver-impregnated specimen, the entire pattern of the nerve distribution, including the branches (small arrowheads) which run away from the vein (V, arrows or inlaid black papers), can be observed. Scale: 1 cm.
Plate III

Photographs showing the intimate relation between the saphenous veins and cutaneous nerves. Viewed from the inner side of the right lower limb. Open arrow indicates the lateral side. Scale: 1 cm.

A. The great saphenous vein and the anterior branch of the femoral nerve in the upper half of the thigh. The nerve (N, arrowheads) approaches the vein (V, arrows) from the lateral side and runs closely along the vein at the middle third of the thigh (asterisks). IG: inguinal lymph node.

B. The small saphenous vein and a cutaneous branch of the common peroneal nerve. The nerve (N, arrowheads) descends in parallel to the vein (V, arrows) in the middle 1/3 of the leg, and runs closely along the vein in the lower third (asterisk).
Diagram showing the relationship between the saphenous veins and cutaneous nerves. Right lower limb. In the thigh region, the anterior cutaneous branch of the femoral nerve (ant.cut), the obturator nerve (obt) or a branch of the saphenous nerve (saph) sometimes runs closely along the great saphenous vein over a short distance, except for cases of the ant.cut. which perforates the sartorius muscle (dotted lines). In the leg region, the saphenous nerve (saph) or the sural nerve (sur) frequently accompanies the great or small saphenous vein, respectively. Although the saphenous nerve emerges into the subcutaneous tissue at various levels, the nerve becomes progressively more intimately related to the vein as it descends, whereas the cutaneous nerve of the calf, mainly the sural nerve, often runs closely along the small saphenous vein. However, there was a significant difference between the great (52.7%) and small (3.4%) saphenous vein cases in the incidence of the adhesive relations in the lower part of the leg.