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# STANDARDIZED PHOTOELECTRIC TECHNIQUE AS ROUTINE METHOD FOR SELECTION OF AMPUTATION LEVEL

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During a period of 11 months 45 amputations, 31 below-knee and 14 above-knee, were performed in 42 patients with gangrene of the lower extremity. A newly introduced standardized photoelectric technique for measurement of local skin perfusion pressure (SPP) was used preoperatively and the result used in selection of the proper amputation level. An overall healing rate of 89 per cent was found. 69 per cent of the amputations were performed below-knee. The healing rates for individual SPP-levels were identical to those obtained with the cumbersome isotope washout technique. The standardized photoelectric technique is simple, rapid and causes the patient only negligible discomfort, allowing repeated measurements on different levels of the leg.

*Key words:* amputation; arterial occlusive disease; ischemia; isotope washout technique; photoelectric plethysmography; skin blood pressure; skin perfusion pressure

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The isotope washout technique for determination of the skin perfusion pressure (Holstein et al. 1977) has proved a reliable method in predicting the prognosis of wound healing following below-knee and above-knee amputations (Holstein et al. 1979a, b, Støckel et al. 1981). This technique, however, is time consuming and often painful. The photoelectric technique (Gyntelberg et al. 1974; Nielsen et al. 1973), which is rapid and causes the patient only negligible discomfort, has recently (Støckel & Brøchner-Mortensen 1981) been shown to give results identical to those of the isotope washout technique with the same precision.

The present paper presents the clinical results of below-knee and above-knee amputations performed after introduction of the photoelectric technique as a routine method for preoperative assessment of proper amputation level.

## PATIENTS AND METHODS

*Patients.* During a period of 11 months (1.7. 1980–31.5.1981) 45 amputations of the lower extremity were performed in 42 patients (24 males and 18 females) with gangrene and/or severe ischemic pain. Selection of amputation level was guided by preoperative determination of the local skin perfusion pressure. There were 31 below-knee (BK) and 14 above-knee (AK) amputations. Pertinent clinical data of the patients appear in Table 1.

*Skin perfusion pressure.* In all but two cases the skin perfusion pressure (SPP) was determined by the photoelectric method as the minimal external pressure required to prevent skin reddening after blanching. The technique has previously been described in detail (Støckel & Brøchner-Mortensen 1981). The technical equipment consisted of a photodetector (Medimatic, Denmark) placed against the skin and connected to a plethysmograph (Medimatic, Denmark). External counter pressure is applied by means of a blood pressure cuff, raised suddenly to suprasystolic level and then

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*Table 1. Distribution of diabetes mellitus, age and level of amputation in 45 below-knee (BK) and above-knee (AK) amputations*

| | No. of cases | Median age years | BK/AK ratio |
|---|---|---|---|
| Diabetes mellitus | 16 | 77.5 (44–88) | 15/1 |
| No diabetes mellitus | 29 | 71.0 (49–93) | 16/13 |

reduced at a constant, slow speed. When inflow of blood in the capillaries of the skin starts the tracing changes direction and SPP is read as the counter pressure at this point. Because of difficulties in interpreting tracing from low pressure extremities the newly introduced standardized reading technique (Støckel & Brøchner-Mortensen 1981) was used in all cases. With this technique the *systolic* blood pressure is measured indirectly by strain-gauge technique on the same level of the leg and guides the reading of the photoelectric tracing. Results of the photoelectric recording are given as the mean value of two determinations. Measurements were performed at two different levels of the leg: the anterolateral side of the calf 10 cm distal to the knee-joint and the anterolateral side of the thigh 10 cm proximal to the upper margin of the patella.

In one patient the standardized photoelectric method could not be used because the crural arteries could not be compressed. The patient had a bilateral below-knee amputation, and in both cases in this patient the skin perfusion pressure was determined preoperatively by the isotope washout technique (Holstein et al. 1977).

*Surgery.* The median interval between the SPP measurement and the operation was 4 days (1–18 days). On the calf simple amputation with a long posterior and short anterior flap was used in 25 cases and myoplasty in six. On the thigh myoplasty was used in all cases. Postoperatively the wounds were loosely covered with Tube-gauze®. Sutures were removed after 22 days (12–42 days).

*Primary healing* was defined as complete healing of the wound at the end of the sixth postoperative week. *Healing by second intention* was defined as healing from the seventh to the end of the twelfth postoperative week possibly after minor surgical revision. Cases where reamputation was necessary were labeled *failures* and cases with a small necrotic area in the cicatrice over a long period and/or minor chronic infection that eventually healed, *chronic stump problems.*

*Statistics.* Fisher's exact test was used.

## RESULTS

*Mortality.* Three patients died during hospitalization 21–34 days after the amputation. Sutures had been removed and the wounds had completely healed.

*Wound healing in below-knee amputations (BK).* Figure 1 shows the relation between the

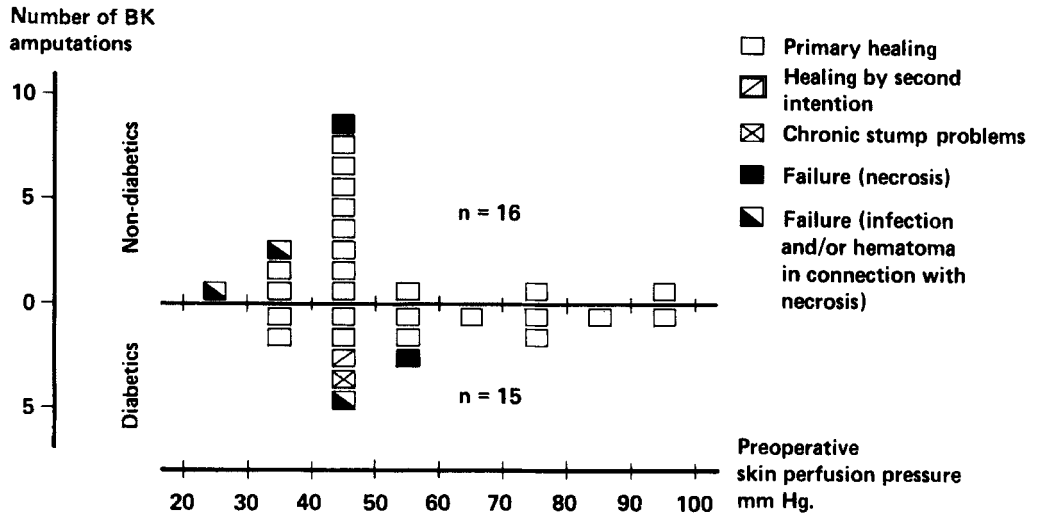


*Figure 1. Healing and wound complications in 31 below-knee (BK) amputations in relation to the preoperative local skin perfusion pressure.*

*Table 2. Healing in 14 above-knee amputations in relation to preoperative skin perfusion pressure at the above-knee level and below-knee level. Asterisk denotes systolic blood pressure. (I: primary healing; II: healing by second intention)*

| Amputation level | Patient No. | Healing | Blood pressure below-knee mm Hg | Blood pressure above-knee mm Hg | Blood pressure above-knee (high) mm Hg |
|---|---|---|---|---|---|
| Above-knee (high) | 1 | I | – | 30 | 40 |
| | 2 | I | 18 | 28 | – |
| | 3 | I | – | 45 | |
| | 4 | I | – | 68 | |
| | 5 | I | – | 110 | |
| | 6 | I | 30* | 35 | |
| | 7 | I | 30* | 40 | |
| Above-knee | 8 | I | 30* | 33 | |
| | 9 | I | 35 | – | |
| | 10 | II | 23 | 55 | |
| | 11 | II | 30 | 50 | |
| | 12 | I | 25 | 30 | |
| | 13 | I | 25 | 65 | |
| | 14 | II | 25 | 45 | |

preoperative skin perfusion pressure (SPP) and wound healing in the 31 cases where a BK amputation was performed. One failure in each of the SPP-groups 21–30 mm Hg, 31–40 mm Hg and 41–50 mm Hg was due to infection and hematoma in connection with necrosis. One failure in each of the SPP-groups 41–50 mm Hg and 51–60 mm Hg was due to necrosis. One patient with an SPP of 45 mm Hg suffered secretion from a fistula for several months but eventually healed. There was no significant difference between diabetics and non-diabetics ($P = 1.00$) with respect to relative number of failures in the SPP interval 31–60 mm Hg (cf. Figure 1).

*Wound healing in above-knee amputations (AK).* Table 2 shows the relation between the preoperative SPP and wound healing in the 14 cases where an AK amputation was performed. All amputations healed primarily or by second intention. Two patients (patients 2 and 9) were amputated at a more proximal level than that of the SPP-measurement because of a low SPP or special clinical conditions. In four cases (patients 1, 3, 4 and 5) measurements on the calf could not be accomplished because of severe pain and spreading gangrene to the knee-joint.

## DISCUSSION

The benefits of using a reliable objective method for prediction of proper amputation level will be seen in a reduced number of reamputations and/or an increased BK/AK ratio compared with the results obtained when selection of amputation level is based on clinical judgement alone (Christensen 1976).

Holstein et al. (1979a, b) showed that there is a strong positive correlation between the skin perfusion pressure and the wound healing following BK and AK amputations. The recent finding (Støckel & Brøchner-Mortensen 1981) that the standardized photoelectric technique gives results identical to those of the isotope washout technique and of equal reproducibility suggested that healing rate in a clinical study of BK and AK amputations would be the same in the individual SPP-groups. This comparison is given in Table 3 showing no significant difference between the two methods in any of the SPP-groups studied. From an ethical point of view comparison of clinical results following amputations with SPP below 20 mm Hg is not possible as the chance of healing at these low pressures is minimal (Holstein et al. 1979a, b). At borderline SPP-values,

*Table 3. The observed healing chances (below-knee amputations) given as per cent when the local skin perfusion pressure is measured preoperatively by the isotope washout technique and the photoelectric technique, respectively. Number of cases is indicated in brackets*

| | Skin perfusion pressure (mm Hg) | |
|---|---|---|
| | 31–40 | >40 |
| Isotope washout technique (Holstein et al. 1979b) | 82% (11) | 93% (29) |
| Photoelectric technique (Present study) | 80% (5) | 88% (25) |
| *P*-value | 1.00 | 0.65 |

especially, clinical factors as surgical technique, postoperative treatment and general condition of the patient can dramatically influence wound healing. In the present study the surgeon in most cases considered a 50 per cent risk of reamputation (SPP: 20–30 mm Hg) too high so that these patients were amputated AK. All AK amputations healed. As previously described by others (Termansen 1977) a significantly higher BK/AK ratio was found in the diabetic group compared with non-diabetics ($P = 0.016$) indicating that patients with diabetes as a group are better candidates for BK amputations than non-diabetics.

The results of the present study indicate that the standardized photoelectric technique can replace the isotope washout technique as the routine method for selection of proper amputation level. The method is simple and rapid and causes the patient only negligible discomfort. Repeated measurements at different levels of the leg are therefore possible. The standardized photoelectric technique is usable in most patients including patients with edema and diabetes mellitus. The isotope washout technique will, however, still be the method of choice in those rare cases where a systolic blood pressure cannot be obtained or in cases where it is not possible to get a technically satisfactory photoelectric tracing because of extremely thin skin at the measure point. In the present study it was thus necessary to use the isotope washout technique twice (same patient) corresponding to 4 per cent of all investigations.

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