

## Measurement of skin perfusion pressure by photoelectric technique— an aid to amputation level selection in arteriosclerotic disease

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### Abstract

During a period of 14 months 60 amputations, 41 below-knee and 19 above-knee, were performed on 54 patients with gangrene of the lower limb. Wound healing was evaluated in 59 amputations. A newly introduced standardized photoelectric technique for measurement of the local skin perfusion pressure (SPP) was used preoperatively, the result of which served as a guide to the selection of the proper amputation level. An overall healing rate of 90 per cent was found. Sixty-eight per cent of the amputations were performed below-knee. The healing rates for individual SPP levels were identical to those obtained with the isotope washout technique. The standardized photoelectric technique is simple and rapid and gives only negligible discomfort to the patient allowing repeated measurements at different levels on the leg.

### Introduction

The isotope washout technique for determination of the skin perfusion pressure (SPP) (Holstein et al, 1977) has proved a reliable method of predicting the chance of wound healing following below-knee (BK) and above-knee (AK) amputations (Holstein et al, 1979 a, b; Støckel et al, 1981). It is, however, time consuming and often painful to the patients. The photoelectric technique (Gyntelberg et al, 1974; Nielsen et al, 1973) which is rapid and non-invasive and gives negligible discomfort to the patients has recently, in a double blind study (Støckel and Brøchner-Mortensen, 1981), been shown to give results identical to those of the isotope washout technique and with the same precision.

This paper presents the clinical results of BK and AK 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 14 months (1.7.1980 – 31.8.1981) 60 amputations of the lower limb were performed on 54 patients (30 males and 24 females) with gangrene and/or severe ischaemic pain. Selection of amputation level was guided by preoperative determination of the local SPP. There were 41 BK and 19 AK amputations. Pertinent clinical data on the patients appear in Table 1. Nine of the 19 patients with diabetes mellitus were treated with insulin. Duration of diabetes was more than ten years in nine patients and less than two years in three patients. Of the 44 patients a major amputation had previously been performed in 15 cases (fourteen contralaterally; one homolaterally) and in four cases bilateral or contralateral reconstructive peripheral arterial surgery (from seven months to ten years before the current amputation) had been performed.

Table 1. Distribution of diabetes mellitus, age and level of amputation in 60 BK and AK amputations.

	No. of cases	Median age years	BK/AK ratio
Diabetes mellitus	19	78 (44-88)	18/1
Without diabetes mellitus	41	73 (49-93)	23/18

#### Skin perfusion pressure

In all cases but two the SPP was determined by the photoelectric method as the minimal

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external pressure required to prevent skin reddening after blanching of the skin. The technique has been described in detail (Støckel and Brøchner-Mortensen, 1981). The technical equipment consisted of a photodetector\* placed against the skin and connected to a plethysmograph\*. External counter pressure, applied by means of a blood pressure cuff, was suddenly raised to suprasystolic level and then reduced to 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 interpreting tracings from low pressure extremities the newly introduced standardized reading technique was used in all cases. By this technique the *systolic* blood pressure measured indirectly by strain-gauge technique at the same level of the leg 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 due to incompressibility of the crural arteries. The patient had bilateral BK amputations, and in both cases the SPP was determined preoperatively by the isotope washout technique (Holstein et al, 1977).

### Surgery

The median time interval between the SPP measurement and the operation was four days (one to nineteen days.) At calf level, amputation with a long posterior and a short anterior flap was used; simple myoplasty was used in all the AK cases. Postoperatively the wounds were loosely covered with Tube-gauze<sup>R</sup>. Sutures were removed after 22 days (12 to 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 called *failures*.

### Statistics

Fisher's exact test was used.

## Results

### Mortality

Four patients died during hospitalization from four to 34 days after the amputation. Sutures had been removed and the wounds were completely healed in three of the patients. One patient with a BK amputation developed gas gangrene and died four days after the operation. This patient is excluded from the material.

### Wound healing in 40 below-knee amputations.

Figure 1 shows the relationship between the preoperative SPP and wound healing in the 40 cases where a BK amputation was performed. One failure in each of the SPP groups 21–30 mm Hg and 31–40 mm Hg was due to infection and haematoma in connection with necrosis. Three failures in the group 41–50 mm Hg were due to necrosis in one case and infection and haematoma in connection with necrosis in two cases. One failure in the SPP group 51–60 mm Hg was due to necrosis. 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.

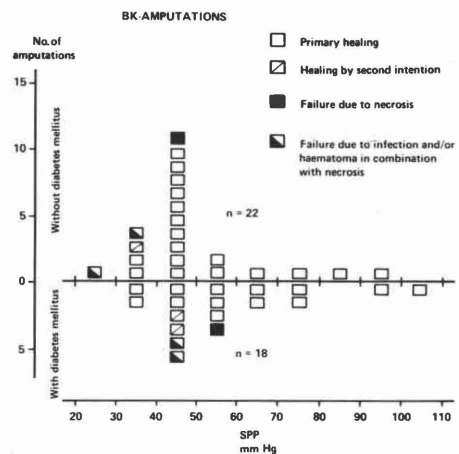


Fig. 1. Healing and wound complications in 40 BK amputations in relation to the preoperative local skin perfusion pressure.

### Wound healing in 19 above-knee amputations (AK).

Figure 2 shows the relationship between the preoperative SPP and wound healing in the 19 cases where an AK amputation was performed. All amputations healed primarily or by second intention.

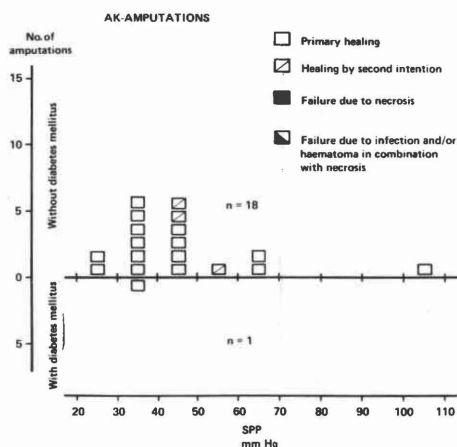


Fig. 2. Healing and wound complications in 19 AK amputations in relation to the preoperative local skin perfusion pressure.

### Discussion

The benefit of using a reliable objective method for the prediction of proper amputation level is shown by a reduction of the number of reamputations and/or by an increase of the BK/AK ratio compared to the results obtained when selection of amputation level is based on clinical judgement alone (Moore, 1973; Christensen, 1976; Kostuik et al, 1976).

Holstein et al, (1979 a, b) showed that there is a strong positive correlation between the SPP and the chance of wound healing following BK and AK amputations. The recent finding (Støckel and Brøchner-Mortensen, 1981) that the standardized photoelectric technique gives results identical to those of the isotope washout technique and that the reproducibility of the two methods was equal suggested that the healing rate in a clinical study of BK and AK amputations would be of comparable size in the individual SPP groups. This comparison is given in Table 2 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, 1979 a, b). At borderline SPP values, especially, clinical factors such as the surgical technique, the postoperative treatment and the general condition of the patient can influence the chance of wound healing. As previously described by

others (Termansen 1977) a significantly higher BK/AK ratio was found in the diabetic group compared to non-diabetics ( $P = 0.019$ ) indicating that patients with diabetes as a group are better candidates for BK amputations than non-diabetics.

Table 2. The observed healing chances (BK amputations) given as per cent when the local SPP is measured preoperatively by the isotope washout technique and the photoelectric technique. Number of cases are indicated in brackets.

	Skin perfusion pressure (mm Hg)	
	31-40	> 40
Isotope washout technique (Holstein et al, 1979 b)	82% (11)	93% (29)
Photoelectric technique (Present study)	83% (6)	88% (33)
P-value	1.00	0.85

The results of the present study indicate that the standardized photoelectric technique can replace the cumbersome isotope washout technique as a routine method for selection of proper amputation level. The method is simple and rapid and gives only negligible discomfort to the patient; repeated measurements at different levels of the leg are therefore possible. The standardized photoelectric technique is usable in most patients including patients with oedema 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 in 2 cases (same patient) corresponding to 3 per cent of all investigations.

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