Acta orthop. scand. 52, 405–408, 1981

RADIOISOTOPE WASHOUT TECHNIQUE AS A ROUTINE METHOD FOR SELECTION OF AMPUTATION LEVEL

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In 36 amputations of the lower extremity the local skin perfusion pressure was measured preoperatively by an isotope washout technique. The result served as a guidance in the selection of amputation level. An overall healing rate of 94 per cent was found with 64 per cent of the amputations being below the knee. Thus, the isotope washout technique, used routinely, gives a reliable preoperative assessment of the chances of wound healing following below-knee and above-knee amputations.

Key words: amputation; isotope washout technique; occlusive arterial disease; skin blood pressure; skin perfusion pressure

Accepted 20.xii.80

Amputations in patients with severe occlusive arterial disease are performed at the most distal level where wound healing may be expected with the aim of saving the knee if possible. To predict healing by clinical means only, however, is difficult and therefore a reliable objective assessment of expected wound healing is necessary. Some reports have demonstrated a positive correlation between the microcirculation of the skin (skin perfusion pressure as well as skin blood flow) and wound healing (Holstein 1973, Holstein et al. 1979a, b, Lassen & Holstein 1974, Moore 1973, Moore 1974). According to Holstein et al. (1979a, b) determination of the local skin perfusion pressure measured by a radioisotope washout technique should be a reliable preoperative procedure to predict the possibility of wound healing after major amputations of the lower extremity. We have adopted this method, and report in this paper the results of amputations of the lower extremity when the isotope washout technique was used as a routine method in daily clinical work.

PATIENTS AND METHODS

Patients. During a period of 15 months (September 1978–January 1980) 38 amputations of the lower extremity were performed in 35 patients after preoperative determination of the skin perfusion pressure. All patients suffered from severe peripheral occlusive arterial disease. There were 23 below-knee (BK) amputations and 15 above-knee (AK) amputations. In 3 patients bilateral amputation was performed. The influence of diabetes on the amputation level is shown in Table 1 together with the age distribution. Ten of the 19 patients with diabetes mellitus were being treated with insulin. The duration of diabetes was more than 10 years in 13 patients and less than 2 years in 2 patients. In 9 patients diabetic complications were present (retinopathy 6; nephropathy 2; neuropathy 1). A major

Table 1. The amputation level related to the presence of diabetes

	No. of cases	Median age years	BK/AK ratio
Diabetes mellitus	19	75.0 (54–84)	14/5=2.8
No diabetes mellitus	19	72.0 (41–79)	9/10=0.9

0001-6470/81/040405-04 $02.50/0

amputation had previously been performed in 13 cases (contralaterally 11; homolaterally 2) and in 6 cases bilateral or homolateral reconstructive peripheral arterial surgery had been performed. In 7 cases the amputation was performed at a more proximal level than that of the pressure determination either guided by a low skin perfusion pressure or because of special clinical conditions.

The isotope washout technique. The technique was that described by Holstein et al. (Holstein et al. 1977, Holstein & Lassen 1973). In principle measurement is made of the minimal external counter-pressure sufficient to stop blood flow in the skin as indicated by cessation of the washout from an intracutaneous depot of $Na^{131}I$ – mixed with histamine. The external counter-pressure was applied by a cuff, and measured via a plastic cushion interposed between the cuff and the skin and connected to a mercury manometer. The external pressure was raised in steps of 10 mmHg and each curve segment was followed for approximately 5 minutes. The skin perfusion pressure (SPP) was determined as the highest counter-pressure, where a minimal washout still occurred, plus 5 mmHg. Measurements were done on the anterolateral side of the calf approximately 10 cm distal to the knee joint and on the anterolateral side of the thigh approximately 10 cm proximal to the upper margin of the patella. If the SPP below the knee was 35 mmHg or more no further measurement was done. If, however, the SPP was 25 mmHg or less, the determination was repeated the next day above the knee. The systemic arm blood pressure was determined repeatedly by auscultation during each investigation. Each patient received 0.5 g potassium iodide perorally for thyroid blockage before the investigation.

Surgery. The median time interval between the SPP measurement and the operation was 4.5 days. The conventional technique with an anterior and a posterior flap was used in 32 cases. Myoplasty was used in 5 cases. Postoperatively the amputation wound was loosely dressed with Tube-gauze®. Sutures were removed after 20 days (8–42 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 had been necessary were called *failures* while cases with a small necrotic area in the cicatrice for a long time and/or minor chronic infection which eventually healed were called *chronic stump problems.*

RESULTS

Two patients died within the first 4 weeks after AK amputation. The wounds were almost healed but the sutures had not yet been removed. Two patients died 4 and 6 weeks, respectively, after AK amputations. The wound was in both cases completely healed and the sutures had been removed. The two latter cases are included in the following analysis of the relation between SPP and wound healing, which thus comprises 36 amputations.

Figure 1 (a) shows the relation between the preoperative SPP and wound healing in the 29 cases where the amputation level coincided with the level of SPP measurement. Nine cases had preoperatively an SPP of 35 mmHg. Eight (89 per cent) of these healed primarily or by second intention. One failure following a BK amputation in a patient without diabetes was due to skin necrosis in connection with hematoma and infection. Seven (88 per cent) of the cases with an SPP of 45 mmHg healed. One failure following a BK amputation in a patient with diabetes was due to skin necrosis. Primary healing was seen in 11 out of the 12 cases with an SPP above 45 mmHg. The exception was a patient with diabetes mellitus who had a small necrotic area in the cicatrice for several weeks. This patient had a marked progression of his peripheral occlusive arterial disease as judged by repeated systolic blood pressure measurements on the contralateral leg. Figure 1 (b) shows the 7 cases where the amputation was performed at a more proximal level than the SPP determination. There were no failures but one patient had chronic stump problems.

The mean SPP in the diabetic patients was 56 mmHg compared to 44 mmHg in the non-diabetic group.

DISCUSSION

In the present material no amputations were performed with a preoperative SPP below 35 mmHg. Our findings that there is a chance of healing of more than 85 per cent when the preoperative SPP is between 30 and 40 mmHg are in accordance with the findings of Holstein and coworkers (Holstein et al. 1979a, b). These

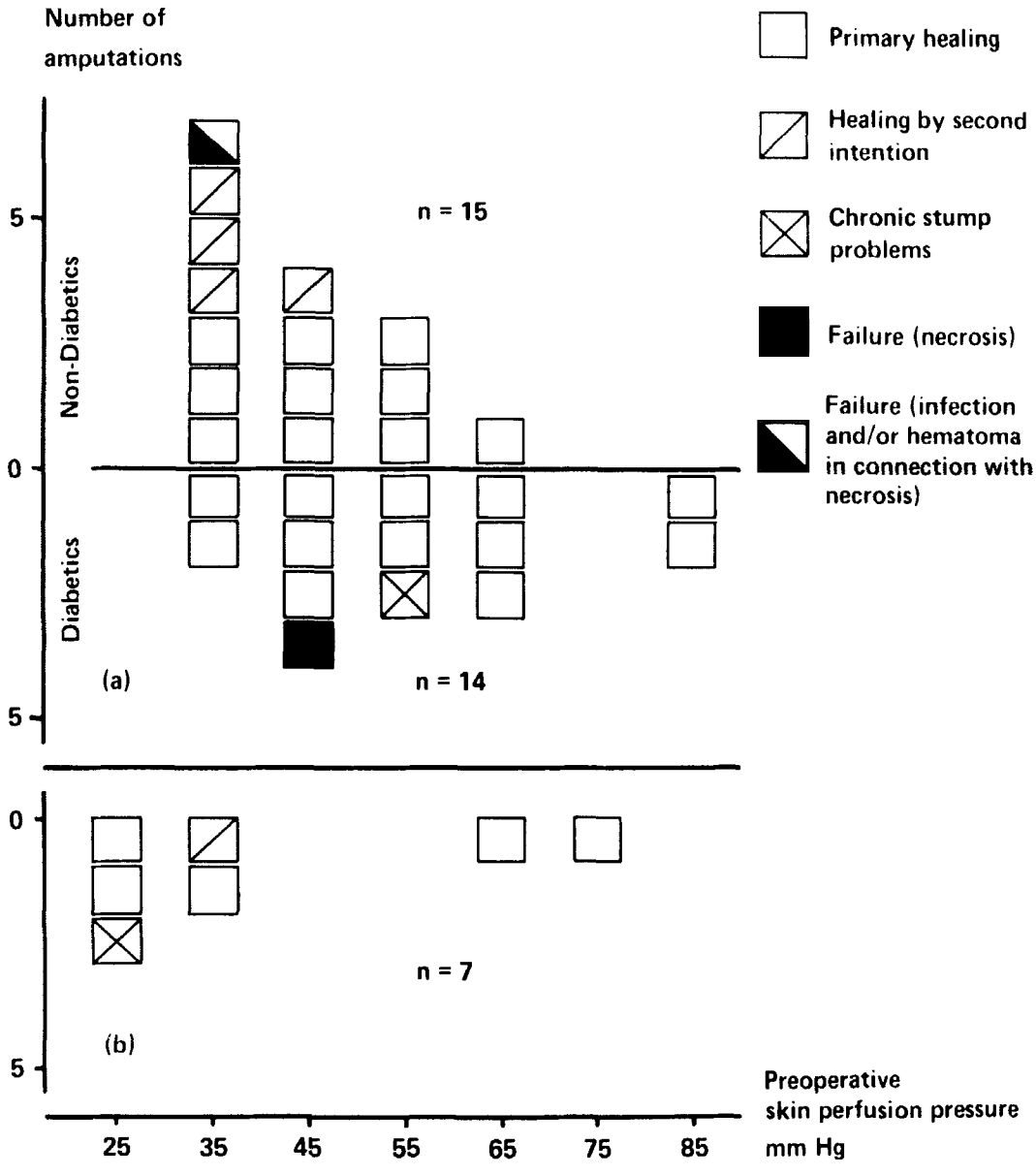

Figure 1. Wound complications and healing in 36 amputations of the lower extremity in relation to the preoperative skin perfusion pressure. (a) Correspondence between level of skin perfusion determination and level of amputation. (b) Amputation proximal to level of skin perfusion determination.

authors moreover found a healing rate of approximately 50 per cent when the preoperative SPP was between 20 and 30 mmHg. In our opinion a 50 per cent risk of reamputation will in most cases be too high. In some cases, however, it will be justified to accept this high risk in order to save the knee or give the patient a longer stump.

As previously reported by other authors (Romano & Burgess 1971, Termansen 1977) we too found a much higher BK/AK ratio in the diabetic group than in the non-diabetics, a finding which is in accordance with the significantly

higher SPP in the diabetic patients. Compared to non-diabetics, diabetics with their vulnerable foot often require amputation at an earlier stage when the level of skin perfusion pressure below the knee is in most cases sufficient for wound healing.

In a large population study from the county of Aalborg, Christensen (1976) found, out of a total of 326 amputations, 6 per cent failures with 27 per cent of the amputations being below the knee. The decision regarding amputation level was based on *clinical* assessment. In our series we also found 6 per cent failures but 64 per cent of the amputations were *below* knee. Even though the present material is not consecutive these results suggest that more knees are saved when the selection of amputation level is guided by the local skin perfusion pressure. Thus routine determination of skin perfusion pressure seems to be a valuable investigation that gives a reliable prediction of wound healing in below-knee and above-knee amputations.

REFERENCES

Christensen, S. (1976) Lower extremity amputations in the county of Aalborg 1961–1971. *Acta Orthop. Scand.* **47**, 329–334.

Holstein, P. (1973) Distal blood pressure as guidance in choice of amputation level. *Scand. J. Clin. Lab. Invest.* (Suppl. 128) **31**, 245–248.

Holstein, P. & Lassen, N. A. (1973) Radioisotope clearance technique for measurement of distal blood pressure in skin and muscles. *Scand. J. Clin. Lab. Invest.* (Suppl. 128) **31**, 143–147.

Holstein, P., Lund, P., Larsen, B. & Schomacker, T. (1977) Skin perfusion pressure measured as the external pressure required to stop isotope washout. Methodological considerations and normal values on the legs. *Scand. J. Clin. Lab. Invest.* **37**, 649–659.

Holstein, P., Dovey, H. & Lassen, N. A. (1979a) Wound healing in above-knee amputations in relation to skin perfusion pressure. *Acta Orthop. Scand.* **50**, 59–66.

Holstein, P., Sager, P. & Lassen, N. A. (1979b) Wound healing in below-knee amputations in relation to skin perfusion pressure. *Acta Orthop. Scand.* **50**, 49–58.

Lassen, N. A. & Holstein, P. (1974) Use of radioisotopes in assessment of distal blood flow and distal blood pressure in arterial insufficiency. *Surg. Clin. North Am.* **54**, 39–55.

Moore, W. S. (1973) Determination of amputation level. Measurement of skin blood flow with Xenon^{133}. *Arch. Surg.* **107**, 798–802.

Moore, W. S. (1974) Skin blood flow and healing. *Bull. Prosthet. Res.* 105–108 (Fall 1974).

Romano, R. L. & Burgess, E. M. (1971) Level selection in lower extremity amputations. *Clin. Orthop.* **74**, 177–184.

Termansen, N. B. (1977) Below-knee amputation for ischaemic gangrene. *Acta Orthop. Scand.* **48**, 311–316.

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