Ischaemic wound complications in above-knee amputations in relation to the skin perfusion pressure*

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Abstract

Healing of the stumps in 59 above-knee amputations was correlated with the local skin perfusion pressure (SPP) measured pre-operatively as the external pressure required to stop isotope washout using ^{131}I or ^{125}I anti-pyrine mixed with histamine. Out of the 11 cases with an SPP below 30 mmHg no fewer than 9 (82 per cent) suffered wound complications. Out of the 48 cases with an SPP above 30 mmHg severe wound complications occurred in only 4 cases (8 per cent). The difference in wound complication rate is highly significant ($P<0.01$). It is concluded that the SPP can be used to predict ischaemic wound complications in above-knee amputations as has previously been shown to be the case in below-knee amputations.

Introduction

It may be surprising that, in spite of increasing knowledge about vascular diseases and in spite of all the modern progress in surgical techniques as well as in objective measurements of the circulation and in postoperative measures, an above-knee (AK) amputation must be considered the only possible treatment in regrettably many dysvascular patients.

Arterial reconstruction can be made only in a limited number of patients suffering from occlusive arterial ischaemic disease. Among those patients who come to major amputation a considerable number suffer from ischaemia to such an extent that amputation below-knee (BK) cannot heal. And not even an AK-amputation is a guarantee against ischaemic wound complications.

In BK-amputations ischaemic wound complications can be predicted by preoperative measurement of the local skin perfusion pressure (SPP) (Holstein et al. 1979). The present study concerns the SPP in relation to wound complications in above-knee amputations.

Patients and methods

Patients:

Sixty-two above-knee amputations in 58 patients were performed after preoperative measurement of the skin perfusion pressure below and above the knee. The distribution according to age, sex and the presence of diabetes mellitus is shown in Table 1. Nine had previously had a contralateral major amputation and in 15 patients the above-knee amputation was secondary to a failed major amputation at a more distal level; in 14 cases below-knee and in one case through-knee (TK). Forty-nine of the patients undergoing AK-amputations were capable of independent walking up to the period of major amputation.

Table 1. Age distribution in 62 cases of above-knee amputation

	41–50	51–60	61–70	71–80	81–90	Total
Cases without diabetes mellitus		3	12	18	12	45
Cases with diabetes mellitus	1	1	4	6	5	17

Male/female ratio: $38/24 = 1.58$. Arithmetic mean age: without diabetes mellitus (DM) 74.0 years. With DM: 72.6 years.

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The surgical technique used was simple amputation at midthigh or low midthigh level, the anterior flap often being longer than the posterior flap. Myoplasty was not used. Suction drainage was employed in most cases and the wound was dressed loosely (Tubegauze[R]). Sutures were removed on the 14th to the 21st postoperative day. The patients were mobilized as soon as possible in a wheelchair or on walking appliances. Prosthetic fitting was undertaken when the stump was well healed.

Measurement of the SPP.

The SPP, which in normal subjects lies slightly above the systemic diastolic blood pressure, was determined as that external counterpressure which was just sufficient to stop the washout of an intradermal depot of radioactive isotopes (Holstein et al. 1977).

Approximately 0·1 ml of a sterile solution containing 10–20 μCi ^{131}I$\bar{}$antipyrine (or 30–40 μCi ^{125}I$\bar{}$antipyrine) and 50 mg histamine diphosphate was injected intradermally and a washout curve was recorded. The external pressure was applied by a blood pressure cuff and measured by a square air-filled plastic cushion (inflatable part, 11 by 11cm) interposed between the labelled skin and the cuff and connected to an ordinary mercury manometer. (Fig. 1). When the washout rate, which
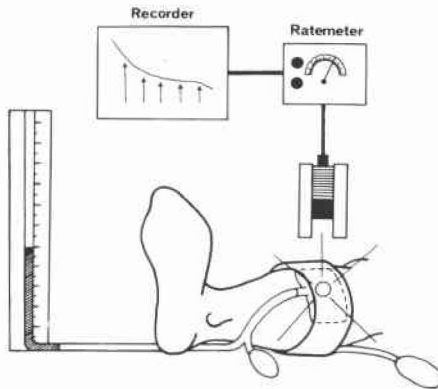

Fig. 1 Measurement of skin perfusion pressure on the calf. The washout from an intradermal depot of ^{131}I–antipyrine mixed with histamine is recorded by a conventional scintillation detector coupled to a ratemeter and written on a penwriter. External counter pressure to the labelled skin area is *applied* stepwise with an ordinary blood pressure cuff and *measured* with an airfilled plastic cushion interposed between the cuff and the depot and connected to a conventional mercury manometer.

accelerates during the first 2 to 15 minutes, had been constant for 3 to 5 minutes, the external pressure was raised in steps resulting in a stepwise decrease in washout rate until cessation. (Fig. 2). At each of the final steps the tracing was observed for about 5 minutes and after washout cessation the external pressure was released to zero in order to secure that the washout was re-established. The washout cessation pressure, viz. the SPP, was determined within an interval of 5 mmHg and was defined as the highest external pressure which allowed a minimal washout to be discerned, plus 3 mmHg.

The sites of measurements were approximately 10 cm distal to the knee joint on the anterolateral side of the calf just superficial to the anterior tibial muscle and 10 cm proximal to the upper margin of the patella on the anterolateral side of the thigh i.e. in most cases
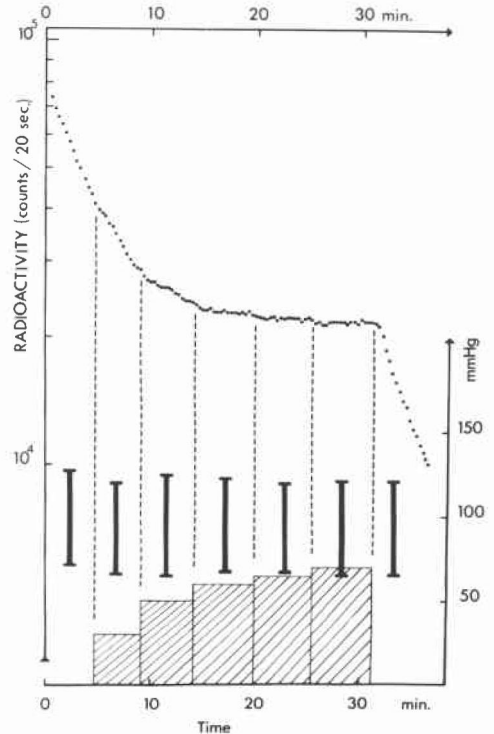

Fig. 2. Replotting of a washout curve. The washout stops at 70 mmHg (skin perfusion pressure = 68 mmHg). The hatched columns indicate the external counter pressure. The vertical bars indicate the auscultatory brachial blood pressure. Observe that the washout is re-established after releasing of the external pressure.

within a range of about 5 cm from the selected levels of amputation.

The patients were examined in the supine position with legs horizontal. Repeated i.v. doses of analgetics (demerole, 35 mg) sufficient to prevent involuntary movements from rest pains were given and, in addition, the legs were supported by sandbags. Conventional auscultatory arm blood pressure was repeatedly measured using a 12 by 26 cm cuff placed around the left arm. Before the examinations the thyroid gland was blocked with 0·5 mg potassium iodide given perorally in solution.

Results

Mortality

Fourteen patients (24 per cent) died postoperatively during hospitalization, six of these (10 per cent) died with severe wound complications of the stump. Two of these had bilateral AK amputations; one died with bilateral stump necrosis and the other died with necrosis of one stump and with the sutures still *in situ* on the other-intact-stump. Six patients died with well healed stumps and two patients died with the sutures not yet removed from an intact stump.

Thus analysis of wound complications in relation to the preoperatively measured SPP (see below) could be made in 59 AK amputations in 56 patients—excluding the three intact stumps with sutures *in situ* at the time of death.

Figure 3 shows the healing of the stump in relation to the SPP. The three cases with an SPP below 20 mmHg all had major wound complications. In one case the patient died with total rupture and severe necrosis of the wound. In two cases severe necrosis postponed the healing, which was not complete until after 4 and 5 months respectively.

Only one out of eight cases (12 per cent) with a preoperative SPP between 20 and 30 mmHg healed primarily. In one case healing of a minimal defect took place by second intention within 6 weeks. The remaining six patients all had major wound complications. In one case severe necrosis delayed the healing for 4 months, in two cases major surgical revisions because of necrosis and infection were necessary and in three cases the patients died with severe necrosis of the stumps. Thus, summarizing the cases with SPP below 30 mmHg, 9 out of 11 (82 per cent) suffered severe wound complications.
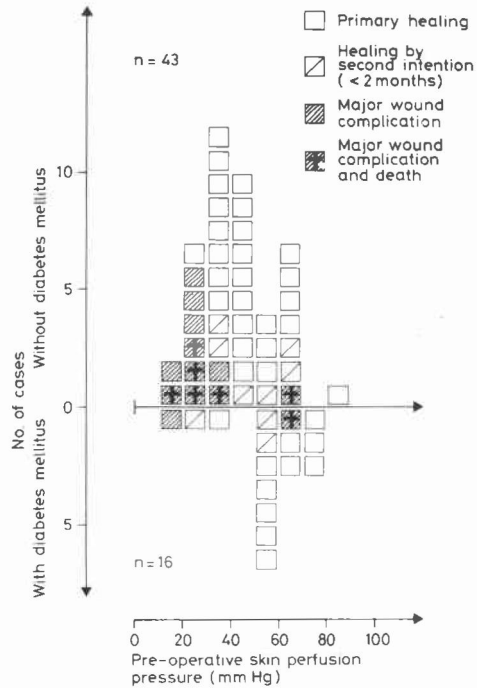

Fig. 3. Wound complications in 59 AK amputations in relation to the local skin perfusion pressure measured preoperatively.

Thirty-six out of the 48 cases (75.0 per cent) with a preoperative SPP of above 30 mmHg healed primarily. In eight cases small defects healed rapidly, i.e. within 2 months. In four cases (8 per cent) major wound complications developed. In two of these cases—both with a preoperative SPP of 30–40 mmHg—i.e. on the borderline of the risk group with an SPP below 30 mmHg—surgical revision because of severe necrosis was carried out. In one of these cases the patient died with necrosis of the revised stump. In two cases with normal SPP, i.e. 60 to 70 mmHg, the patients died with severe wound complications; one with infection of the wound and sepsis and the other with rupture of the infected wound. The clinical picture, a swelling, warm, red stump in these two cases with normal SPP and infection was very different from the necrotic appearance of the low pressure stumps.

These differences in primary healing rate and in major wound complication rate in the various SPP groups are highly significant for the total number of cases and for the 43 non-diabetic cases (Fig. 3). In the 16 diabetic cases there were only 2

major wound complications (12 per cent) compared with 11 major complications (26 per cent) in the non-diabetic group (0.5<P<0.10). The SPP in the diabetic group, which averaged 58.1 mmHg, was however, significantly higher than in the non-diabetic group where the average was 42.9 mmHg (P<0.01) and only 2 of the diabetic cases had an SPP below 30 mmHg.

Among the 14 cases with AK amputations secondary to failed BK amputations the wound healed primarily in 12 cases. In one case the wound healed slowly (in 6 months) and in one case the patient died from wound infection. The average SPP at the BK level before the BK amputations in these 14 cases was 31.0 mmHg (range 8–63 mmHg), as against 54.3 mmHg (range 23–68 mmHg) at the AK level before the AK amputations (P<0.01).

The TK amputation which failed had preoperatively an SPP of 28 mmHg below the knee. The revision to AK amputation healed primarily after measurements of the SPP above the knee, which was 38 mmHg.

Among the 44 cases where an AK amputation was the primary operation, the SPP *below* the knee was less than 30 mmHg in 32 cases i.e. with great risk of ischaemic complications at that low level. In 12 cases the SPP *below* the knee was greater than 30 mmHg. The general condition of these patients, however, was so poor that a primary AK amputation was considered the safest treatment and the AK amputation healed primarily in 10 cases and secondarily, caused by very small defects, in 2 cases.

Rehabilitation

The patients returned to their own homes in 28 out of 48 cases (58 per cent). Of the 49 patients who could walk prior to major amputation, rehabilitation as regards walking with a prosthesis was obtained in 20 cases (41 per cent). The walking ability was not regained in the remaining 29 cases due to death in 9 cases, to poor mental and physical condition in 15 cases and to bilateral major amputation in 5 cases.

The average time spent in hospital per AK amputation was 15.8 weeks. Table 2 shows that the *preoperative* period was about nine times longer in patients with failed major amputation at a lower level. Rehabilitation or an attempt at rehabilitation as regards walking increased the *postoperative* time about three to five times. Wound complications did not on average increase the period of hospitalization, but some of these patients died in the early postoperative period.

Table 2 Number of weeks spent in hospital in relation to primary or secondary AK amputation and to rehabilitation

No. of AK amputations	No. of patients	Type of AK amputation	Weeks in hospital			
			preoperatively		postoperatively	
			mean*	range	mean*	range
47	43	Primary	1.8	(0.1−8.0)	10.2	(0.5−52.0)
15	15	Secondary to failed BK or TK amputation	16.9	(4.0−39.0)	12.1	(0.5−48.0)

No. of AK amputations	No. of patients	Rehabilitation	preoperatively		postoperatively	
			mean*	range	mean*	range
20	20	Discharged walking	6.8	(0.1−38.5)	15.3	(3.0−31.0)
8	8	Failed attempt at walking	8.8	(0.5−24.0)	24.1	(6.0−56.0)
34	30	No attempt at walking	3.5	(0.5−9.0)	4.7	(0.5−40.0)

* Arithmetic mean per AK amputation.

Discussion

The healing of the AK amputations correlated significantly with the preoperative SPP. The poor results in patients with an SPP below 30 mmHg agree with previous findings in BK amputations (Holstein et al. 1979).

Apart from a preliminary report on this series (Holstein 1973) no studies of wound healing in above-knee stumps in relation to objective measurements of the arterial supply have previously been published. Our rate of primary healing (62.7 per cent) is, however, of the same order as that reported in larger series in the literature (Dale & Capps 1959, Schlitt & Serlin 1960, Warren & Kihn 1968, Hall & Schucksmith 1971, Kihn et al. 1972).

The high mortality (24 per cent during hospitalization) reflects the often poor condition of the patients undergoing AK amputations. Our figure falls within the range of mortality rates of about 10–40 per cent in larger series in the literature (Dale & Capps 1959, Lempke et al. 1963, Warren & Kihn 1968, Hansson 1964, Otteman & Stahlgren 1965, Hall & Schucksmith 1971).

In discussing the importance of the SPP in relation to AK amputations one must distinguish between two different groups of patients. The first group consists of patients who have lost the ability to walk for reasons other than the peripheral ischaemia and in these patients the aim of the amputation is to relieve a painful useless extremity with a minimum of discomfort. In 13 cases in our series the patients belonged to this category. In six cases the patients suffered wound complications which in four cases were related to an SPP below 30 mmHg. These findings point towards the selection of a short stump in cases of inadequate blood supply in a weak patient. Only if the blood supply is adequate should a long stump, which is more comfortable during sitting and when moving in bed, be chosen.

The level selection is more difficult in the second group where the patients have been able to walk up to the time of amputation. In these cases the result of the treatment should be considered satisfactory only if the ability to walk is regained by means of a prosthesis; 41 per cent achieved this in the series. In principle a long stump facilitates walking with a prosthesis and when this advantage is added to the previously mentioned comfort during sitting and moving in bed it seems justified to take the risk of ischaemic wound complications in order to obtain a long stump. Slow healing may be obtained even when the SPP is of the order of 20 to 30 mmHg. But this must be balanced against the risk of loss of ambulation in the event of a long period with a painful, slowly healing ulcer prohibiting prosthetic training—and early surgical revision should be considered in case of ulcers in order to shorten the healing time.

Compared with our figures for BK amputations (Holstein et al. 1979) the average duration of hospitalization for AK amputations was less. This finding agrees with Weaver & Marshalls observations (1973). A high mortality, a number of patients discharged to nursing homes soon after surgery and only a few reamputations, reduced the average period of hospitalization in patients undergoing AK amputations.

To summarize, the SPP is a very reliable means of predicting ischaemic wound complications in AK amputations. The implications of wound complications are, however, very variable, ranging from healing by second intention with preservation of the stump length to a life-threatening complication. If ischaemic wound complications are to be avoided meticulous surgery is required and in non-mobile weak patients a short stump length is advocated in the case of a low SPP.

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