Selection of lower limb amputation level not aided by transcutaneous pO_2 measurements

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The transcutaneous oxygen pressure measurements were evaluated as supplementary ones for predicting stump healing in 58 below-the-knee and 16 above-the-knee amputations; the lower level was selected if the skin perfusion pressure was greater than 30 mm Hg below the knee. The failure rates in below-the-knee and above-the-knee amputations were 17 and 25 percent, respectively, and unrelated to the transcutaneous oxygen pressure measured at the amputation level. We conclude that no further information is acquired by measuring transcutaneous oxygen pressure.

Skin perfusion pressure is widely used for assessing the optimum level of amputation (Holstein 1982). Recently, transcutaneous oxygen pressure has emerged as a potential measure (Burgess et al. 1982, Franzeck et al. 1982, Ratliff et al. 1984, Christensen and Klaerke 1986, Dowd 1987, Malone et al. 1987). We investigated the reliability of the transcutaneous oxygen pressure measurement for predicting stump healing in a consecutive series of lower limb amputations where the level selection was guided by the skin perfusion pressure.

Patients and methods

Patients. The amputation level was guided in 71 below-the- knee and 24 above-the-knee amputations by skin perfusion pressure measured 10 cm distal to the knee joint (Støckel et al. 1982). In 84 of these 95 cases, transcutaneous oxygen pressure was measured in the region that later on was selected as the amputation level. The 11 failures of transcutaneous oxygen pressure determination were due to technical reasons (unstable curve or insufficient initial decline of the curve) in 6 cases, edema in the region caused by recently performed femoropopliteal bypass operation in 3 cases, and uncooperative patient in 2 cases. Ten amputations were excluded because the patients died before the healing state could be assessed. The present material thus consisted of 74 amputations in 72 patients (Table 1).

Transcutaneous oxygen pressure was measured preoperatively anterolaterally 10 cm below the knee and 10 cm above the knee with two Radiometer TCM2 oxygen monitors connected to a chart recorder. The electrode (modified Clark E5230 with a polypropylene membrane) was calibrated to atmospheric oxygen pressure. Before transcutaneous oxygen pressure was measured, the area was shaved, and thereafter the skin was degreased with spirit. The electrode was attached to the skin by self-adhesive rings, and the heater in the electrode was set at 45 °C. Transcutaneous oxygen-pressure recordings were read after 20 min. The transcutaneous oxygen pressure values were unkown to the surgeon.

Amputation technique

The below-the-knee amputations were performed using equal sagittal flaps in all but six amputations where a long posterior flap was used. In the thigh, equal anterior and posterior myocutaneous flaps were used. Postoperatively, the wound was loosely covered with a bandage. The sutures were removed 3 weeks later. Prophylactic antibiotics were given in one half of the cases. Primary wound healing was defined as complete healing of the wound at the end of the sixth postoperative week. Secondary healing, possibly including minor revisions, was defined as healing being complete after the sixth week. Reamputations at a higher level

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Table 1. 74 amputations where transcutaneous oxygen pressure could be evaluated. The data for diabetes, sex, and age are related to legs

Amputation level	No. of amputations (No. of patients)	Mean age (range)	Female	Male	Insulin-dependent diabetes
Below the knee	58 (56)	71 (38–95)	34	24	24 (8)
Above the knee	16 (16)	70 (55–94)	8	8	2 (0)

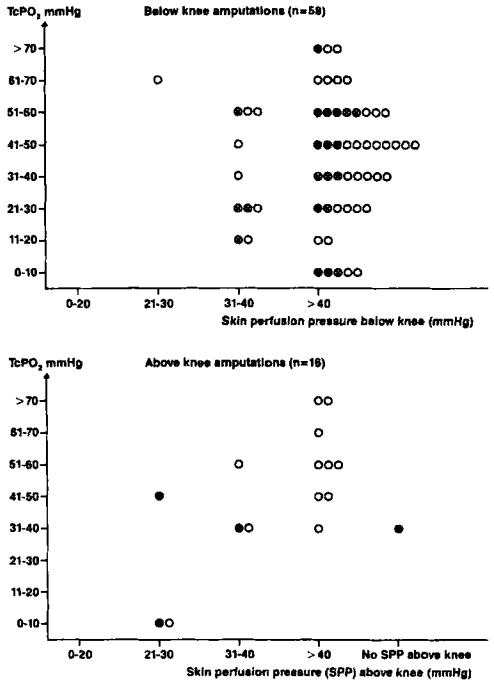

Figure 1. The skin perfusion pressures and transcutaneous oxygen pressures ($TcPO_2$) measured at the selected amputation level. O: Primary healing. ⊗: Secondary healing. ●: Failure.

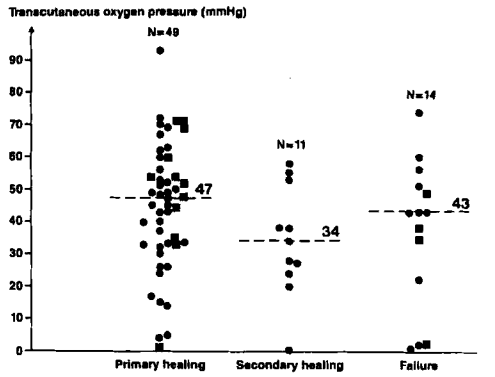

Figure 2. The transcutaneous oxygen pressure at the level of amputation in relation to healing. ● below-the-knee amputation; ■ above-the-knee amputation. Median values are given by ---.

were defined as failures.

The chi-square test, Kruskal-Wallis test, and Fischer exact probability test were used. A significance level of 0.05 was chosen.

Results

Below-the-knee amputations. There were 10 failures among 58 amputations. In all but one the skin perfusion pressure was greater than 30 mmHg. The failure rate of 17 percent was unrelated to the level of transcutaneous oxygen pressure (Figure 1). The same held true in the 11 amputations with delayed healing. The failure rate was equal in diabetics and nondiabetics (4/24 vs. 6/34).

Above-the-knee amputations. There were five failures among 16 amputations. In 14 above-the-knee amputations the skin perfusion pressure below the knee was less than 31 mmHg. Again, the failures were unrelated to the level of transcutaneous oxygen pressure (Figure 1).

The distribution of the individual transcutaneous oxygen pressure values did not differ between the groups primary healing, secondary healing, and failure (Figure 2).

Transcutaneous oxygen pressure was measured below the knee in 15 out of the 16 above-the-knee amputations. Seven measurements ranged from 0 to 5 mmHg; five ranged from 18 to 40 mmHg, and three > 40 mmHg. On analyzing the clinical data of the seven failures with a transcutaneous oxygen pressure greater or equal to 40 mmHg, we found that parameters indicating poor general medical condition were present in 4 patients.

Discussion

The level of skin blood flow is determined by the perfusion pressure and the microcirculatory resistance to flow. However, there is a considerably interindividual variation in the resistance (Kastrup et al. 1987), and a high resistance and a decreased distensibility of the vascular bed might cause insufficient perfusion in spite of a normal perfusion pressure. Because transcutaneous oxygen pressure varies with skin blood flow (Eichhoff and Jacobsen 1980), it was thought that a low transcutaneous oxygen pressure could predict such failures. However, our results show that this was not the case: healing took place even at very low transcutaneous oxygen pressures, and amputations failed to heal in 14 cases with normal transcutaneous oxygen pressures. The best measure of the tissue viability is the capillary oxygen pressure, but there is a lack of a close relationship to the transcutaneous oxygen pressure due to the interindividual variation in the gradient across the epidermal layer (Jaszczak 1988, Falstie-Jensen et al. 1988) and due to variation in the diffusibility of oxygen in the skin. Also different handling of the skin previous to measurement of the transcutaneous oxygen pressure plays a role (Jaszczak 1988).

Our results are consistent with those of Ratliff et al. (1982) and Franzeck et al. (1982), who found healing even at very low transcutaneous oxygen pressures, but they are contradictory to other studies reporting a lower limit of transcutaneous oxygen pressure under which amputations failed to heal (Burgess et al. 1982, Christensen and Klaerke 1986, Dowd 1987). Edema may cause falsely low measures of transcutaneous oxygen pressure. Three cases with a recent femoropopliteal bypass operation were excluded from analysis because of edema in the region of measurement. In these cases we observed extremely low values of transcutaneous oxygen pressure. However, healing took place in all but 1 case. Apart from these cases, edema was not specifically looked for in the present series.

In contradiction to other investigations (Burgess et al. 1982, Christensen and Klaerke 1986, Dowd 1987, Franzeck et al. 1982, Ratliff et al. 1984), we could not identify a limit of transcutaneous oxygen pressure above which healing takes place in all the cases. Our interpretation is that these failures are not caused by insufficient microcirculation at the time of amputation, but are related to other risk factors; this is supported by our analysis of the clinical data of the seven failures with transcutaneous oxygen pressure ≥40 mmHg. These clinical observations indicate that some effort probably should be made to identify other risk facts than low perfusion, such as, poor nutritional status, infection, suboptimal surgical technique, and poor postoperative stump handling.

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