Skin Blood Flow in Diabetic Dermopathy

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Background: Diabetic dermopathy has been termed the most common cutaneous finding in diabetes, occurring in as many as 40% of diabetic patients older than 50 years. Using laser Doppler technology, we tested the hypothesis that dermopathy lesions represented areas of cutaneous ischemia.

Design: A survey of cutaneous blood flow in diabetic patients with dermopathy and comparison of values with those in nondiabetic patients.

Setting: Outpatient clinic specializing in diabetes.

Patients: A consecutive sample of 61 diabetic patients (52 men and 9 women; mean ± SEM age, 58±2 years) with dermopathy had blood flow measurements performed at the sites of dermopathy and at contiguous uninvolved sites. Flow values were also determined at several reference sites and compared with those in 41 nondiabetic control subjects (30 men and 11 women; mean age, 53±3 years).

Results: Heat-stimulated blood flow values at the knee, ankle, and toe were about 50% lower for the dermopathy patients than for the nondiabetic controls. Yet, despite their reduced skin blood flow reserve, the dermopathy lesions did not show relative ischemia. At the basal temperature of 35°C, flow was 1.1 ± 0.1 mL/min per 100 g of tissue in apparently normal skin vs 2.2 ± 0.2 at dermopathy sites; at 44°C, flow at the normal sites was 7.9 ± 0.3 mL/min per 100 g of tissue vs 12.9 ± 0.6 at dermopathy sites (P < .01 for both comparisons).

Conclusions: Although patients with diabetic dermopathy exhibited reduced skin blood flow compared with nondiabetic volunteers, flow levels were considerably higher at the dermopathy sites than at contiguous uninvolved skin sites. These results refute the hypothesis that diabetic dermopathy represents local ischemia. However, it is still possible that the scarring represented by dermopathy lesions is related to decreased skin perfusion due to diabetes.

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PATIENT SELECTION

We included male and female patients with type 1 or type 2 diabetes and evident diabetic dermopathy. Informed consent was obtained from each subject after the nature of all procedures and the protection of confidentiality had been fully explained.

SKIN BLOOD FLOW MEASUREMENTS

We used a Vasamedic Model 403B laser Doppler device (Vasamedics Inc, St Paul, Minn), which was designed based upon the original theoretical model of Bonner and Nossal. A low-power solid-state laser diode provides the coherent light source that is delivered through a fiber optic line to a probe affixed to the skin with an adhesive ring. Two separate fiber optic lines gather the photons from the skin surface and return them to a photodetector that converts them to a direct current (DC) electrical signal related to the level of scatter from stationary tissue and an additional small alternating current (AC) signal generated by Doppler-shifted photons. The AC/DC ratio is converted to the average number of Doppler shifts per photon. That number is proportional to the blood volume. A signal-processing algorithm converts a time domain autocorrelation to a frequency domain, which gives a mean frequency proportional to blood velocity. Blood flow is the product of linearized volume and velocity. A calibration factor of 6 mL·100 g⁻¹·min⁻¹·100 Hz has been derived on the basis of theoretical calculations to convert the laser Doppler flow parameter to conventional blood flow units and has been verified in numerous tissues using several reference techniques.

A Vasamedic module TCM 420 was used for controlling local skin temperature. Doppler fiber laser optic probes were inserted into a 19-mm-diameter thermal head attached to a separate solid-state controller. The temperature was controlled in the range of ±0.5°C of set point. The probe was placed so that the fiber optic ends did not lie directly over a vein or hair follicle. Mean flow was measured using a 5-second averaging time to encompass cardiac pulsatile activity.

We measured flow at sites of diabetic dermopathy. We also obtained measurements at nearby uninvolved sites with apparently normal skin. As reference points, we also performed readings at the following locations: (1) the plantar surface of the tip of the index finger (finger pulp); (2) the dorsal surface of the distal phalanx of the index finger, immediately proximal to the nail bed (finger dorsum); (3) the plantar surface of the tip of the great toe (toe pulp); (4) the extensor surface of the distal phalanx of the great toe, immediately proximal to the nail bed (toe dorsum); (5) the pre Tibial surface of the leg immediately below the patella (knee); and (6) the dorsal surface of the ankle, between the medial and lateral malleolus (ankle). The finger and toe pulps have a high density of arteriovenous anastomoses with a low resistance and high flow. The knee and ankle have a primarily nutritive capillary perfusion with high resistance and low flow. The dorsal surfaces of the finger and toe have a relatively high, primarily nutritive capillary perfusion.

STATISTICAL ANALYSIS

Comparisons were carried out by standard analysis of variance techniques. All results are presented as mean ± SEM.

RESULTS

We measured flow in 61 patients (52 men and 9 women; mean age, 58 ± 2 years) with diabetic dermopathy. The average duration of diabetes was 15 ± 1 years. The average hemoglobin A1c value in the diabetic group was 8.3% ± 0.2%. Retinopathy was observed in 45% of the patients, microalbuminuria in 50%, and neuropathy in 76%. Six patients had elevated serum creatinine levels. In this group of 61 patients, we performed measurements at a total of 243 sites of diabetic dermopathy and at 195 sites with no evident skin lesions. In addition, we measured flow at 26 sites of large scars unrelated to diabetes. There were 41 nondiabetic control subjects (30 men and 11 women; mean age, 53 ± 3 years). We performed measurements at the finger, toe, knee, and ankle in these control subjects. Consistent with our previous findings, blood flow values at 35°C at these sites on the extremities were similar in diabetic and nondiabetic subjects, but, at 44°C, flow values for the dermopathy patients were about 50% lower at the knee, ankle, and toe dorsum (Table).

Yet, despite the reduced skin blood flow reserve in the patients with dermopathy, the lesions themselves did not show relative ischemia. To the contrary, flow at the dermopathy sites was significantly higher than at contiguous uninvolved apparently normal skin sites (Figure). At the basal temperature of 35°C, flow was 1.1 ± 0.1 mL/min per 100 g of tissue in normal skin vs 2.2 ± 0.2 at dermopathy sites; at 44°C, flow at the normal sites was 7.9 ± 0.3 mL/min per 100 g of tissue vs 12.9 ± 0.6 at dermopathy sites (P < .01 for both comparisons). The readings obtained at diabetic dermopathy sites were similar to those obtained at scar sites unrelated to diabetes (Figure).

COMMENT

Although diabetic dermopathy is a well-recognized cutaneous manifestation of diabetes, the etiology of this condition is unknown. In prior work, we have demonstrated that skin blood flow reserve is reduced in diabetic
patients. This decrease in skin blood flow reserve correlates with increasing duration of diabetes and with the presence of retinopathy and proteinuria, but not with neuropathy. Therefore, we have proposed that decreased skin blood flow reserve represents a true cutaneous diabetic microangiopathy.

We explored the possibility that diabetic dermopathy is related to this cutaneous microangiopathy. Our patients had an average duration of diabetes of about 15 years, with a high incidence of retinopathy, microalbuminuria, and neuropathy. They had significantly decreased skin blood flow reserve compared with a control group of nondiabetic subjects, yet blood flow values at the dermopathy sites were not low as would be expected if they represent areas of ischemia. To the contrary, flow values were considerably higher at dermopathy sites than at contiguous uninvolved skin. The flow values at dermopathy sites were similar to those found in scar sites. Other investigators have documented that blood flow is increased in hypertrophic but not atrophic scars. These results suggest that diabetic dermopathy lesions are, in fact, scars. Patients typically ascribe their dermopathy lesions to prior trauma. In fact, it has been possible to produce lesions resembling diabetic dermopathy by local thermal trauma.

Although our results appear to refute the hypothesis that diabetic dermopathy represents local ischemia, it is still plausible that decreased skin blood flow leads to the development of diabetic dermopathy. It is possible that an active cutaneous flow is required for healing to proceed with minimal scar formation. A pronounced hyperemic response occurs early in the process of wound healing. Studies of burn wounds suggest that wounds that heal rapidly without scarring have higher initial perfusion than those with slow healing. Perhaps skin perfusion in diabetic patients may be insufficient to heal wounds without scarring. Even minor trauma may lead to scar formation in these patients. This could be the etiology of the lesions of diabetic dermopathy. Further studies must focus on this possibility.

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REFERENCES