ORIGINAL PAPERS

Thermographic patterns in migraine

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Summary. The Authors performed a thermographic (T.) examination on 53 migrainous patients both during and between attacks. Thirty-one patients (58.4%) had an abnormal T. during an attack, and 8 of them (1 5.1%) showed persistent abnormalities between attacks, No correlation was found between positive T. findings and clinical data. Besides T. asymmetry, the presence of a warm spot at the internal orbital angle was observed, this sign occurring more frequently than T. asymmetry.

Key.words: migraine, thermography, asymmetrical temperature, warm spot

A) INTRODUCTION

Thermography (T.) has yielded useful information concerning skin temperature and, by inference, about skin blood flow. This technique was used [1,2,3] to demonstrate a decrease in skin temperature on the headache side of some migraine patients The results suggested that blood is shunted away from the skin during a migraine attack. Thereafter, T. has been used in the evaluation of orofacial pain' and ice cream headache.' In the attempt to review the incidence of T. abnormalities in migraine, 53 migrainous patients were examined. Moreover, the patients' clinical data were correlated with T. findings.

6) PATIENTS AND METHODS

Fifty three migrainous patients were examined both during and between attacks. Diagnosis was established on a clinical and pharmacological field, using provocative tests (with either histamine or reserpine) and extinction tests (ergotamine injection, common carotid a. compression).

Forty one patients had common migraine, whereas 12 suffered from classical migraine. The mean age was 34.2 yrs (range, 14-65 years). There were 33 females and 20 males.

An AGA Thermovision equipment was used. All patients were cooled for 10 mins before examination at a room temperature of 19-21°C. T. were obtained both in frontal and lateral view. Polaroid type 668 film was used for recording the thermal image.

. Asymmetrical temperature was considered to be present when there was a difference of at least 1°C between the 2 sides (Fig. 1). The T. pictures were analyzed also for the presence of a warm spot at the internal orbital angle, which frequently occurred in these patients. A warm spot was present when the internal orbital angle was at least 1°C warmer than the controlateral one (Fig. 2).

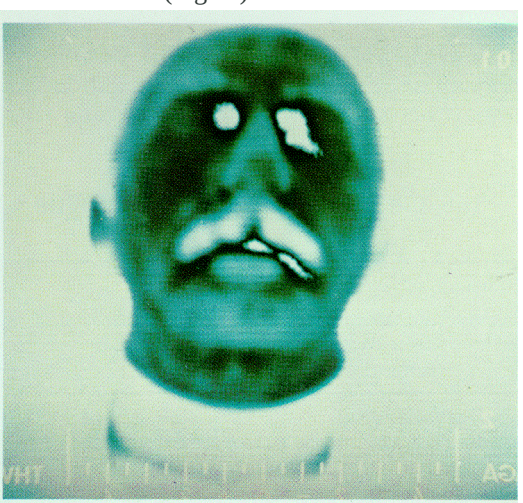

Fig. 1. Asymmetrical temperature during acute migraine attack.

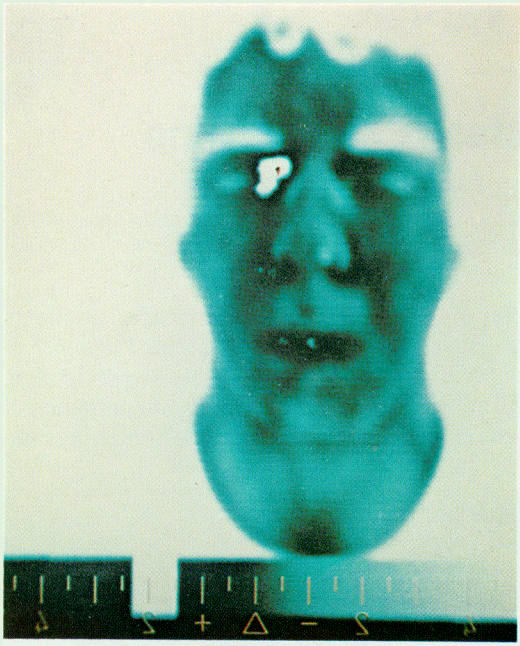

Fig. 2. Warm spot at the internal orbital angle.

C) RESULTS

Clinical features of headache are listed in Tab. I and Tab. II. During an acute attack, T. abnormalities were found in 8 out of 12 patients with classical migraine (66.7%), and in 23 out of 41 patients with common migraine (56.1%). This difference is not statistically significant. Between attacks, abnormalities persisted in 3 subjects with classical migraine (25.0%) and in 5 subjects with common migraine (12.2%) (Fig. 3 and Fig. 4). These results are summarized in Tab. III. No correlation was found between T. abnormalities and the

Tab. I. Clinical features of migraine (53 patients).

Preliminary visual symptoms	16153 (30.2%)
Unilateral pain	29/53 (54.7%)
Throbbing headache	38153 (71.7%)
Nausea and vomiting	34153 (64.2%)
Positive family history	19153 (35.8%)

Tab. II. Frequency and duration of migraine attacks (53 patients).

Frequency:	1 iwk	11/53 (20.8%)
	1/month	26/53 (49.0%)
	1/yr	16/53 (30.2%)
Duration:	1-24 h	29/53 (54.7%)
	longer than 24 h	24/53 (45.3%)

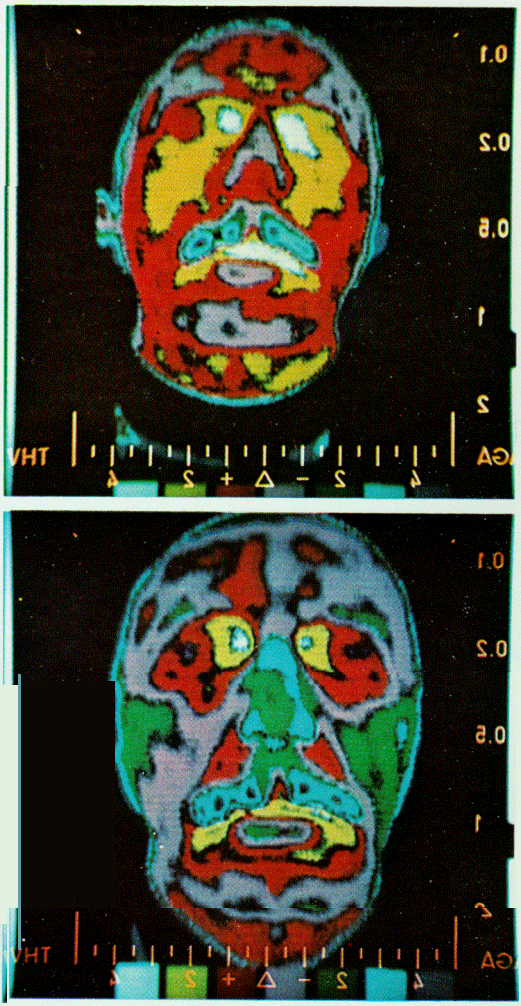

Fig. 3 A-B. Same patient as Fig. 1. A) during the attacks, there is a warm spot at the internal orbital angle. B) Between attacks, the warm spot is not observable.

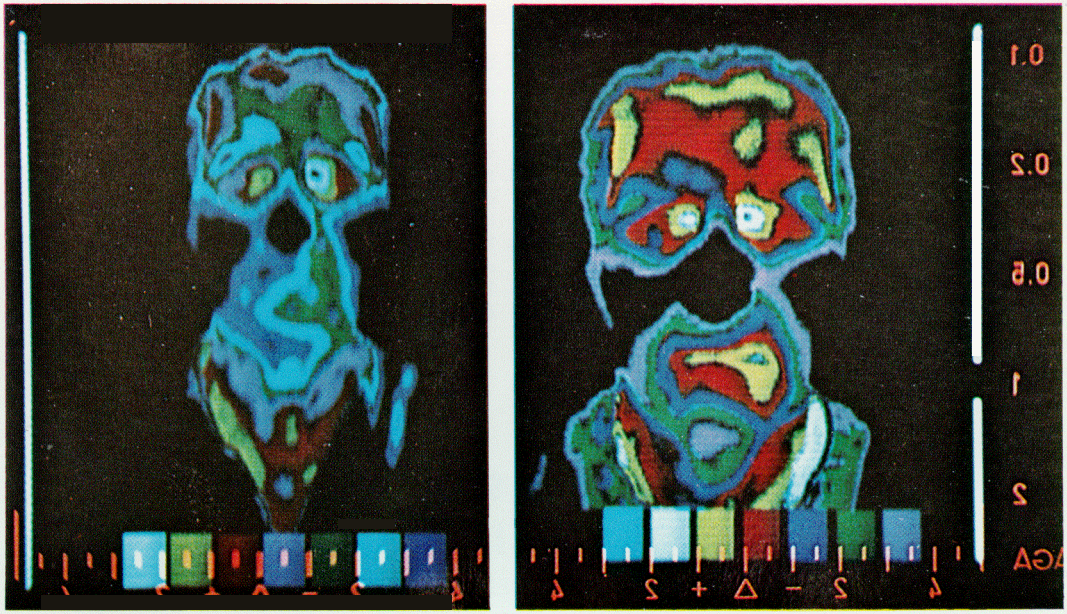

Fig. 4 A-B. Same patient as Fig. 2. A) during the attacks, there is asymmetry of the facial temperature. B) Between attacks, there is persistence of symmetrical temperature.

Tab. III. Thermographic findings during and between attacks (53 patients).

Clinlcal patterns	NO	Asymmetrical temperature	Warm spot	Asymmetrlcal temperdture and/or warm sppot
Classical migraine	12			
during attacks		2112 (166%)	6/1 2 (50 0%)	8/1 2 (66 7%)
between attacks		Oil 2	3112 (25 0%)	3/1 2 (25 0%)
Common migraine	41			
during attacks		10141 (24 4%)	18141 (43 9%)	23141 (56 1%)
between attacks		3141 (7 3%)	2141 (4 9%)	5141 (1 2 2%)
Total	53			
during attacks		12153 (22 6%)	24153 (45.2%)	31153 (58 4%)
between attacks		3153 (5 6%)	5153 (9 4%)	8153 (1 5 0%)

presence of preliminary visual symptoms, unilateral or throbbing pain, nausea, frequency and duration of attacks, positive family history.

D) DISCUSSION

LANCE' found abnormal T. in l0/13 (76%) migraine patients during attacks. Personal findings, in a greater number of patients, show a low er percentage of positive findings (58,4%), with better results in classical than in common migraine. Thus, the value of T. in migraine appears to be limited, even if it may be a useful diagnostic tool in atypical cases.

The presence of a warm spot at the internal orbital angle in migraine has not been reported

in previous papers. According to personal experience, this sign is more sensitive than asymmetrical temperature. Medical literature' reports about the occurrence of a cold spot in cluster headache, ascribing it to diminished blood flow in the ophthalmic a. and in the internal carotid a. In migraine, the warm spot may suggest an increased blood flow in the ophthalmic a., possibly caused by shunting of blood from the external to the internal carotid a.

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Thermography of stress fractures in military personel

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Summary. Lower leg and pelvis tele-thermography (T.) was performed on 66 military recruits suspected of stress fractures at 84 various sites. Radiological (R.) signs of fractures were found at 64 sites. In 29 of these the T. were positive and in 35 negative. The best correlation between R. and T. was found in the metatarsals, but from 25 fractures in the tibial shaft, T. was positive only in 9. T. brings no essential addition to the routine methods in diagnosis of stress fractures in military personel.

Key words: stress fracture, thermography.

A) INTRODUCTION

March or stress fractures are relatively common among military recruits even today.[4,11,14] There are reports of cases among civilians, too, especially in athletes[7,8] and occasionally in children and older women.[3,12] The diagnosis is usually revealed by the callus seen in radiograms (R.). The vascular hyperactivity of the active callus tissue is well known and is a source of heat emission. To date, there have been relatively few reports on thermography (T.) in the diagnosis of osseous processes, especially fractures.[1,2,5,10] The use of contact T. in the study of osseous consolidation was just described.[6] No report of T. in stress fractures has been found by the Authors. Aim of this investigation was to study the value of T. in stress fractures in military personel.

B) PATIENTS AND METHODS

The subjects were 66 military recruits referred consecutively to the Central Military Hospital, Helsinki, for clinically suspected stress fractures. Six of the patients were athletes, the others non-athletes. Their average age was 20.6 yrs (range 17.8 - 26.5 yrs). The mean body weight was 70 kg (range 52 - 86 kg) and the mean height 180 cm (range 166 - 196 cm). The series consisted of 32 white-collar workers and 34 labourers. They came from all branches of the military, but the basic training programme was practically the same for everyone. Conventional R. were taken of all the clinically suspected sites. T. (Aga-Thermovision 680 Medical) was performed for suspected stress fracture in lower legs and pelvis. The T. was taken from a mirror above the

patient. The examinations were carried out in a supine position, legs elevated 15 - 20" above the horizontal. With few exceptions, the patients were also examined in the prone position. Before T. the patients were allowed to lie at rest for about 10 mins. A temperature difference of 1.0% was considered significant when using a sensitivity setting of 10°C. Images were recorded on Polaroid films.

CI RESULTS

The symptoms were: pain during or after marches or terrain exercises, progressively increasing with continued stress and usually ceasing when at rest; limping; local tenderness; sometimes swelling at the easily palpable sites. Symptoms were found at 84 various sites in the 66 patients. According to R. there were bilateral stress fractures in 9 patients. Tab. I shows the correlation of the R. and T. findings. These were divided into 4 groups (I - IV). In groups III and IV follow-up R. were taken from 1 to 4 wks later, but they all remained negative. Tab. II shows the distribution of the sites of suspected stress fractures and the corresponding R. and T. findings. The average time from the appearance of the symptoms to the R. examination was 5 wks in group I, 4.5 wks in group II and 3.5 wks in groups III and IV. The average time from the first medical examination to the R. was 1.5 wks in group I, 3.5 wks in group II and 2.5 wks in groups III and IV. Figs. 1, 2 and 3 show some typical stress fractures with corresponding T.

D) DISCUSSION

A definitive diagnosis of stress fracture can be made only with R. examination. Thus, if the R. is negative and remains negative in the re-examinations, a diagnosis of stress fracture cannot be made (groups III and IV). Of course, a positive T. without R. findings may represent a stress fracture in situ, but may also represent some other heat emitting process.

In stress fractures (groups I and II) the best correlation between R. and T. was seen in the metatarsals (Fig. 1). This was not surprising, since the soft tissue in this area is very thin (Tab. II). However, in 1 case, with clinical symptoms and R. evidence of stress fracture of the first metatarsal, the T. was negative.

T. was also normal in more than half of the stress fractures in the calcaneus, in most of the fractures in the tibia1 condyles and in 1 of the 2 fibular shaft fractures (Tab. II). Also in these areas the soft tissue is thin. It is difficult to exaplain the negative T. in these cases.

Of the 25 stress fractures in the tibia1 shaft T. was, surprisingly, negative in 16 cases. An analysis of the respective R. shows that in 1 case the callus was already old (homogeneous and sharp-lined) and that in 7 cases the damage was relatively small with only a slight callus formation. On the contrary, the periostal callus was distinct in 8 cases and looked active. The clinical symptoms were evidenf too. The stress fracture in the tibia1 shaft occurs mostly on the medio-dorsal aspect of this cross-sectionally triangular bone. The strong calf musculature interfering with the heat emission may be one explanation for the negative T.

Because the shaft of the tibia is one of the most common sites of stress fractures,[8,9,11] it would appear that T. is not a very good means of diagnosis unlike the results reported on traumatic fractures.[5,10] On the other hand, the osseous damage in traumatic situations is fairly extensive, and the callus as the source of

Tab. I. dorrelation between radiographic and thermographic findings.

Radiography \ Thermography	Positive	Negative	Total
Positive	Group I 29	Group II 35	64
Negative	Group III 8	Group IV 12	20
Total	37	47	84

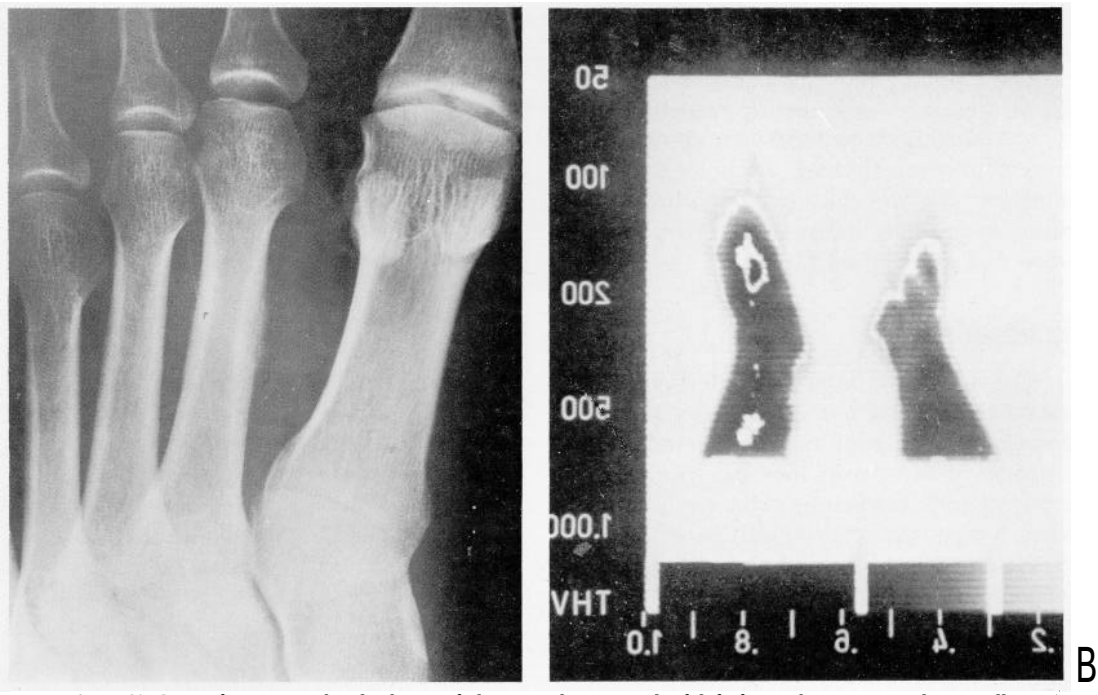

Fig. 1 A-B. A) Stress fracture in the diaphysis of the second metatarsal of left foot. There is a moderate callus. B) Hyperthermic area in the metatarsal region.

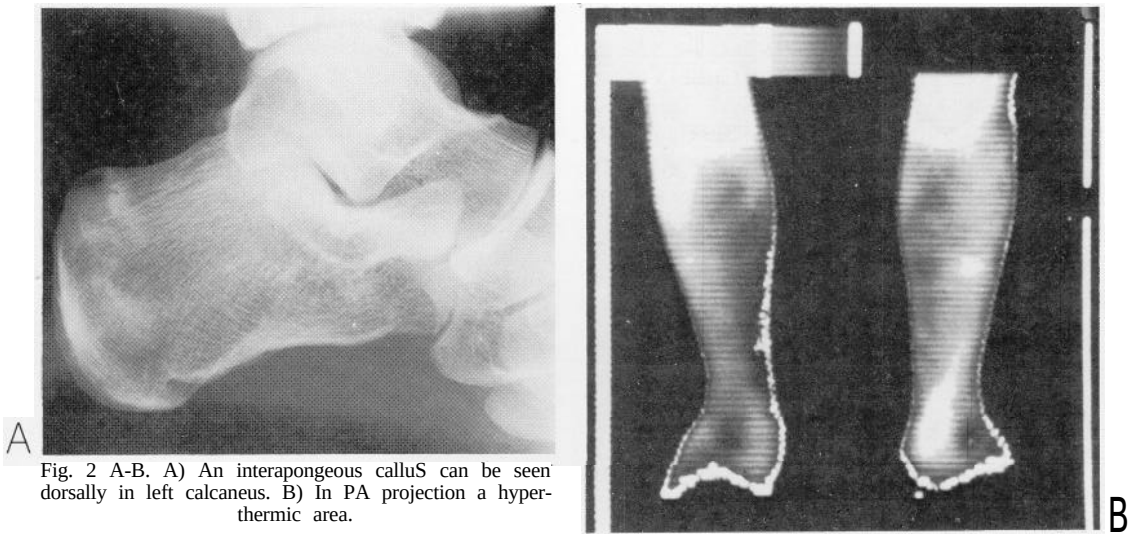

Fig. 2 A-B. A) An interapongeous calluS can be seen dorsally in left calcaneus. B) In PA projection a hyperthermic area.

heat emission is more pronounced. This can perhaps explain the better correlation between T. and R. findings. PRATS et al.[10] recorded no increased heat emission until 8 days after the trauma. At this point the R. usually also shows the first signs of callus formation. In stress fractures, too, positive R. findings cannot usually be expected during the first wk after appearance of the symptoms.[13]

The average duration of symptoms in groups I and II was similar but the average time from the first medical examination to the R.

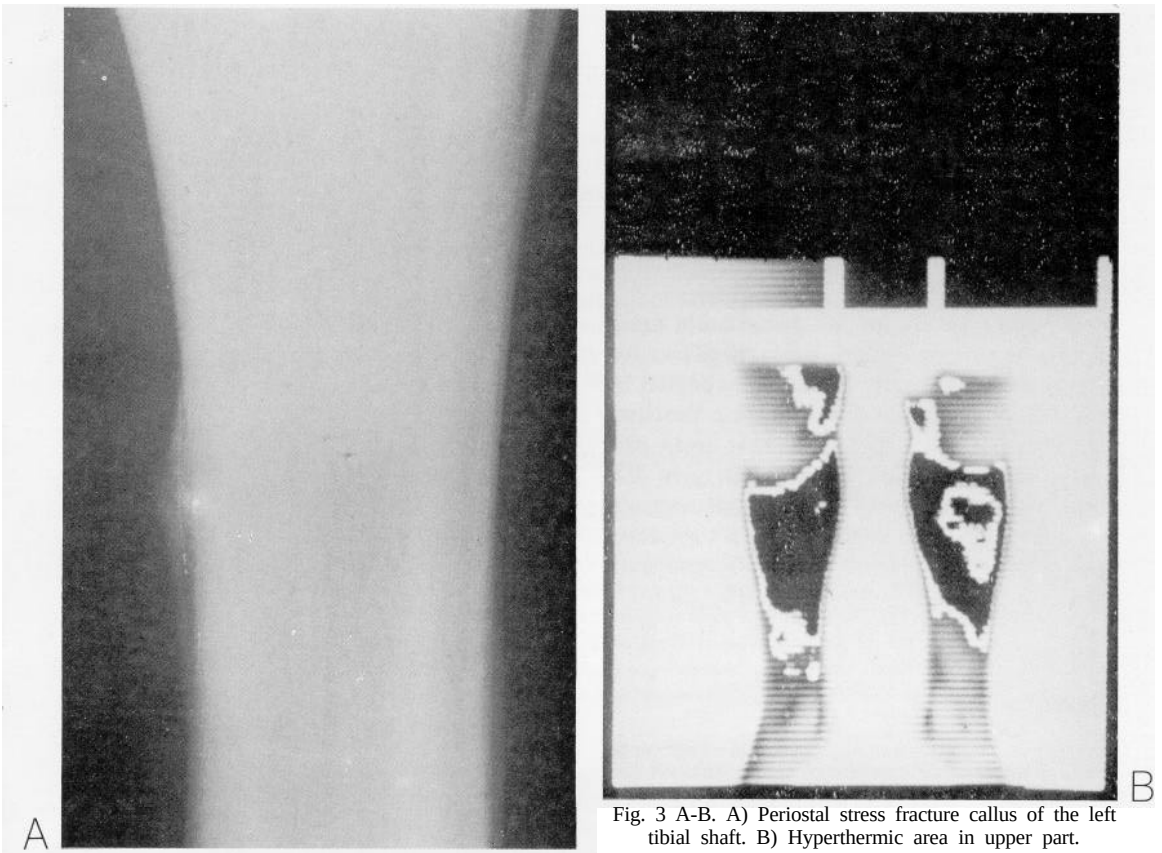

Fig. 3 A-B. A) Periostal stress fracture callus of the left tibial shaft. B) Hyperthermic area in upper part.

Tab. II. Distribution of sites of suspected stress fractures with the corresponding radiographic and thermographic findings.

Suspected site of stress fracture	Groups of T.-R. correlations			
	Group I (R+T+)	Group II (R+T−)	Group III (R−T+)	Group IV (R−T−)
Pubic arch	116	5/6		
Femoral shaft				1/1
Distal end of femur			I / I	
Tibial condyl	1/5	4/5		
TIblal shaft	9/40	16/40	4/40	11/40
Flbular shaft	1/2	1/2		
Calcaneus	6/14	8/14		
Metatarsal	10/14	1/14	3/14	
Os cuneiforme	1/1			
Total	29/84	35/84	8184	12/84

diagnosis was 2 wks longer in the group with negative T. (group II). It is possible that since painful activities had been avoided on doctors' orders, the heat emission of the fracture had decreased, and so the T. remained negative although the R. was positive.

It should be pointed out that stress fractures often occur bilaterally;[3,4,14] this fact must be remembered when comparing the T. patterns in both legs.

Although the T. in one pubic arch stress fracture was positive in this study (negative in4 cases), the best results are to be expected in areas where the soft tissue is thin, e.g. foot and wrist. On the other hand, in these areas palpation and inspection alone often give the same information, and T. alone is not accurate enough for specific diagnosis. As a completly non-invasive and simule method T. could be used as a complementary diagnostic tool.

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Changes in muscle rest blood flow and superficial temperature of the legs associated with therapeutic defibrinogenation

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Summary. Controlled pharmacological defibrinogenation was performed in 11 patients with peripheral arterial occlusive disease (3rd and 4th stage of Fontaine's classification). A ^{133}Xe clearance technique and thermographic investigation were applied to evaluate the effect of defibrinogenation on the peripheral blood flow in the affected and the non-affected legs. The muscle rest blood flow and the skin temperature of the affected legs significantly increased during the period of administration of defibrinogenating agent. The peripheral circulation seemed to improve considerably within the course of defibrinogenation and in 9 patients the symptoms were evidently alleviated at the end of the treatment.

Key words: arteriosclerosis, defibrinogenation, thermography, ^{133}Xe.

A) INTRODUCTION

In the past 10 yrs many Authors have suggested that defibrinogenation with thrombin-like enzymes may result in multi-factorial improvement of the blood flow properties in patients with diffuse peripheral arterial disease.[4,5,6,8] It has been known that reduction of blood fibrinogen level results in diminution of plasma and whole blood viscosity;[7] moreover a significant increase in the leg blood flow as measured by DOPPLER perfusion pressure and calf plethysmography was demonstrated in patients with peripheral arterial occlusive disease treated with defibrinogenating agents.[4,5,8] The aim of this study was to investigate the effect of pharmacological delibrinogenation on the muscle rest blood flow and superficial temperature in patients with the symptoms of «claudicatio intermittens» and rest or night pain in the presence of arterial occlusive disease.

B) PATIENTS AND METHODS

Eleven patients unsuitable for surgical reconstruction (FONTAINE stage 3rd and 4th) with clinical symptoms of peripheral arterial occlusive disease were studied before, during and at the end of pharmacological delibrinogenation. The age of the patients ranged from 52 to 71 yrs, the mean age being 57.5 yrs.

Pharmacological defibrinogenation was achieved with intra-venous or subcutaneous administration of defibrase (Bathroxobin, Pentapharm, Basel). The initial dose of 2 units/kg body weight was followed by daily injection of 1 unit/kg over a period of 14 days. Plasma fibrinogen level was measured as a thrombin-clottable protein before, and each 48 h of defibrase therapy.

1. Radio-isotopic examination

For the study of the rest muscle blood flow ^{133}Xe dissolved in sterile 0,9 per cent saline was used. With the patient resting in the supine position a dose of 50 μ Ci of ^{133}Xe in a volume of 0,15 ml was injected into the solal muscle of each calf. Ten mins after injection the recording of the disappearance of the indicator was made by a collimated scintillation detector placed above the depot. The scintillation crystal was coupled to a ratemeter and a strip-chart recorder. The decrease in the counting rate was then recorded continuously for the next 15 mins. Recordings, every min of ^{133}Xe radioactivity in CPM (counts per min) were obtained from linear clearance curves plotted manually against time on semi-logarithmic graph paper. For calculation of muscle rest blood flow the following equation was used:

$$MBF_{Xe} = 161 \cdot \frac{D}{\Delta t} \cdot \frac{ml/min}{100\ g} \qquad (12)$$

where 161 is a steady coefficient, D is the slope of the tangent of the curve in decimal logarithmic units and A t is the time in min.

The rest muscle blood flow studies were performed before, at the 7th and 14th day of treatment with defibrase.

2. Thermographic examination

The patient was examined in the ward. The room temperature at the time of thermographic study (T.) was between 20-21°C. The patient was lying with the legs elevated 15" for about 30 mins in order to achieve thermal equilibration. The T. views of the dorsum of both feet were simultaneously studied by means of AGA Medical 680 equipment. The highest temperature of the selected portion from the displayed image of the dorsum of the foot was measured each day for the whole period of defibrase administration (14 days). The different values of temperature of the same point (values y) at different days (values x) were plotted on the graph paper and the relationship between x and y parameters was expressed in the form of a straight line (cc the least squares method))), which was calculated according to the equation":

$$y = mx + c$$

where the values of m (expressing the slope of the line) and c (the value in which the straight line cuts the axis of y) are given from the following formula:

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$$m = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{n}}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}$$

$$c = \frac{(\Sigma x)(\Sigma y) - (\Sigma y)(\Sigma x^2)}{(\Sigma x)^2 - n(\Sigma x^2)}$$

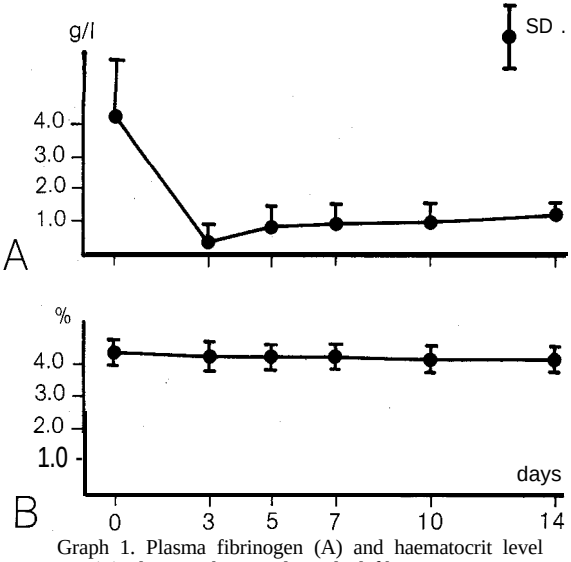
Symbols:

Σx = total of x values; Σy = total of y values; Σx^2 = total of squared x values; Σxy = total of multiplyied x values by y values; n = number of days

The difference quotient $\frac{\Delta T}{\Delta t}$ was calculated, where ΔT was the difference temperature between the 1st (y_1) and the 14th (y_{14}) day of defibrase administration, and Δt expressed the time of treatment.

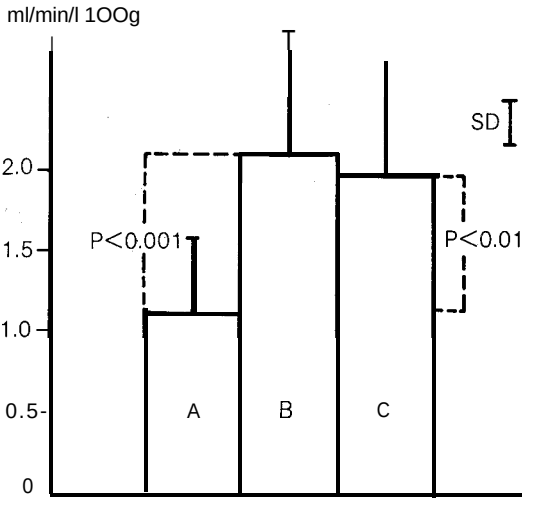
C) RESULTS

1. In the group of 11 patients defibrase administration resulted in a fall of **plasma fibrinogen level** (Graph 1) from 4.3±1.8 g/l (initial values) to 0.97±0.4 g/l (the mean of values obtained at 3rd, 5th, 7th, 10th and 14th day) and this fall was highly significant ($p<0,005$).



Graph 1. Plasma fibrinogen (A) and haematocrit level (B) during pharmacological defibrinogenation.

2. The **muscle blood flow (MBF)** values in 17 affected legs during defibrase therapy were significantly greater then those seen in the pre-treatment period (Graph 2). The MBF



Graph 2. Muscle blood flow during pharmacological defibrinogenation. A: before the treatment. B: after 7 days defibrase administration. C: after 14 days defibrase administration.

initial values were 1.15±0.44 ml/min/100 g, then at the 7th day of treatment 2.11±0.71 ml/min/100 g and at the 14th day 1.90±0.69 ml/min/100 g. The MBF values obtained during defibrase treatment in the 4 non-affected legs did not differ statistically from basal data.

3. During the 2 wks therapy with defibrase the significant increase of the **superficial temperature** of the dorsum of the feet affected by peripheral arterial disease was noted. This increase was in relation to the increase of the rest muscle blood flow shown by the isotopic technique. At the beginning of defibrase administration the mean temperature of the dorsum in the 17 affected feet was 30.53 °C±1.96°C and 33.81°C±1.55°C in the non-affected legs. A 14 day period of defibrase treatment resulted in increase of the dorsal temperature of the studied legs. At the end of defibrase administration the mean temperature of the selected portion in the affected feet was 33.76°C±1.21°C and 35.51°C±1.06°C in 4 non-affected legs.

The observed increase of the temperature of the affected legs was significant ($p<0,005$) and the temperature difference of the same point recorded at the 1st and 14th day of defibrase administration was 3.23°C±1.40°C. The difference quotient $\frac{\Delta T}{\Delta t}$ was 0.2307. There was

no significant increase of the superficial temperature of the feet in non-affected legs at the end of defibrase treatment.

D) DISCUSSION

The effect of defibrinogenation on the blood flow properties in patients with peripheral arterial occlusive disease has been studied in several Centres in Europe, however only indirect methods of flow measurements such as plethysmography and ^{133}Xe clearance from the skin were used.[4,8] Blood flow measurements with the use of ^{133}Xe technique have been introduced into the clinical practice by LASSEN.[7] The value of this method has been stressed by several Investigators particularly in cases where the effect of sympatectomy or vasodilators had to be established.[7]

The present study, based on the direct measurements of the muscle blood flow with the use of ^{133}Xe technique and T. examination, has clearly shown the beneficial effect of defibrinogenation on the capillary blood flow in patients suffering from peripheral arterial occlusion disease. It has been known that the flow resistance within the circulation is determined by the geometry of the vessel on the one hand and by the viscosity of the blood on the other[3] hand. The most important determinants of the whole blood viscosity are red cell concentration, plasma fibrinogen level and red cell deformibility. It may be then suggested that the decrease of plasma fibrinogen level produced by defibrase resulted in reduction of plasma viscosity and consequently in diminution of flow resistance within the capillary network of the studied muscles.

According to this study it may be suggested that the longterm follow-up of T. of the legs in patients suffering from peripheral arterial disease seems to be worthy of clinical trial. The non-invasive character of T. examination, enables daily measurement of the temperature distribution over the lower extremities. The changes of the local temperature of the dorsum of the feet may provide information about the sub-clinical improvement or decrease of the peripheral blood flow resulting in recording of higher or lower temperatures respectively.[1,2,9,13] It should be noted that the results obtained from these methods for monitoring the peripheral blood circulation corresponded to the improvement of the clinical status of the treated patients. On the basis of the clinical symptoms of the peripheral arterial disease all but 2 patients were verified to stage 2nd of FONTAINE classification at the end of defibrase therapy.

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