Increased survival of ischaemic musculocutaneous flaps in rats after acupuncture

G. JANSEN*, T. LUNDEBERG*, U. E. SAMUELSON*† and M. THOMAS*

*Department of Physiology, Karolinska Institutet, and †Department of Plastic Surgery, Karolinska Hospital, Stockholm, Sweden

The effects of acupuncture on survival of ischaemic musculocutaneous flaps were investigated in the rat. A dorsal cranially based standard flap (2 x 7 cm) was elevated and sutured back in position. The percentage survival of the flaps was estimated after 6 days. Manual acupuncture, electro-acupuncture but not superficial acupuncture significantly increased the survival of the flaps compared to untreated controls. The highest flap survival (92%) was obtained with repeated post-operative high-intensity electro-acupuncture. It is concluded that acupuncture treatment markedly increases experimental flap survival and may be of clinical importance for treatment of local ischaemia.

Key words: acupuncture, flap survival, ischaemic musculocutaneous flaps.

Details of the physiological mechanism underlying the action of acupuncture are incomplete and contradictory.

There is at present evidence that the analgesic effect of acupuncture is at least partly mediated through inputs into the central nervous system from muscle afferents (Wang et al. 1985). Evidence for the vascular effects of acupuncture is scanty. In animal studies it has been shown that acupuncture, like stimulation of the sciatic nerve in spontaneously hypertensive rats, lowers their blood pressure (Yao et al. 1982). These effects were naloxone-reversible (Thorén & Hoffman 1986); conversely anaesthetized dogs stimulated on the upper lip with acupuncture showed rises in blood pressure which were not naloxone-reversible (Lee & Clifford 1979).

More recent interest has centred on the peripheral control of blood flow by vasoactive peptides (Rowell 1981). Peripheral electrical stimulation has recently been used to study vascular effects on ischaemia of experimental and clinical skin flaps (Kjartansson et al. 1988 a, b, Lundeberg et al. 1988).

The aim of the present study was to see if acupuncture produced vascular changes in skin flaps raised on rats and further to see, if such changes occurred, which particular modes of acupuncture induced them and also what was the optimum time for such interference following the raising of the flap.

MATERIALS AND METHODS

The study was carried out on 110 female albino rats (Sprague–Dawley, weight 180–220 g). The rats were anaesthetized with chloralhydrate (0.4 g kg⁻¹), shaved on the back and a flap designed according to a standard pattern, 2 cm wide and 7 cm long, based on a line between the caudal part of the scapulae (McFarlane et al. 1956, Kjartansson et al. 1988). It was raised from the deep fascia of muscle and included the superficial fascia, panniculus carnosus, subcutaneous tissue and skin. After raising, the flap was sutured back in position. Before each acupuncture treatment the rats were anaesthetized with chloralhydrate.

Three acupuncture stimulation techniques were
examined: electro-acupuncture, superficial acupuncture and manual acupuncture. During superficial acupuncture two stainless steel acupuncture needles (Aido, Stockholm) were inserted at the base of the flap to a depth of 0.1 cm and retained for 60 min. During manual acupuncture two stainless steel acupuncture needles were inserted at the base of the flap to a depth of 0.5 cm and manual stimulation carried out by rotating the needles backwards and forwards through 180°. The rotation was repeated every 5 min for 10 s during a 60-min treatment period. During electro-acupuncture continuous electrical stimulation was used instead of manual stimulation. The needles were connected to an acupuncture pulse stimulator (Enraf Nonius, Delft) producing alternating square-wave pulses, of 0.2 ms. During high-frequency electro-acupuncture the frequency was 80 Hz and during low-frequency electro-acupuncture 2 Hz.

The rats received acupuncture treatment as follows (Fig. 1). Ten rats received high-intensity (20 mA), low-frequency electro-acupuncture at the base of the flap for 1 h before surgery. Ten rats received low-intensity (2 mA), low-frequency electro-acupuncture at the base of the flap for 1 h after surgery. Ten rats received superficial acupuncture at the base of the flap for 1 h after surgery (group 1). Ten rats received high-intensity, low-frequency electro-acupuncture at the base of the flap for 1 h after surgery (group 2). Ten rats received low-intensity (2 mA), low-frequency electro-acupuncture at the base of the flap for 1 h after surgery (group 3). Twenty rats received high-intensity, low-frequency electro-acupuncture at the base of the flap for 1 h on the third day after surgery (group 4). Ten rats received high-intensity, high-frequency electro-acupuncture at the base of the flap for 1 h after surgery and for 1 h on the following 2 days (group 5). Ten rats received high-intensity, low-frequency electro-acupuncture at the base of the flap for 1 h after surgery and for 1 h on the following 2 days (group 6). Ten rats received superficial acupuncture at the base of the flap for 1 h after surgery and for 1 h on the following 2 days (group 7). Ten rats received manual acupuncture at the base of the flap for 1 h after surgery and on the following 2 days after surgery (group 8). Two groups of controls were used. Ten rats were anaesthetized during surgery and also on the following 2 days (group 9). Ten rats were anaesthetized only during surgery (group 10).

The percentage survival of the flaps was estimated after 6 days.

For statistical analyses of flap survival between the different groups, the Mann–Whitney U-test was used.

**RESULTS**

In the controls, i.e., rats undergoing surgery and anaesthetized once (group 10) or anaesthetized three times (group 9), 43.1% and 36.4% respectively of the flaps survived (Fig. 1). Rats anaesthetized three times had a lower flap survival than those anaesthetized once, which, however, was not significant. Statistical analysis of the acupuncture effects was carried out by comparing the acupuncture-treated groups with the control groups with the corresponding number of anaesthesias (Fig. 1). Electro-acupuncture and manual acupuncture significantly increased flap survival compared with controls in all treated groups (Fig. 1). The highest percentage flap survival (92.9%) was seen in the group of rats receiving high-intensity, low-frequency electro-acupuncture stimulation for 3 days post-operatively (group 6). Superficial acupuncture (group 7) did not significantly increase the flap survival (34.4%).

Comparisons of flap survival between the different stimulation technique groups show that there is a significant difference ($P < 0.002$) between manual acupuncture and superficial
Acupuncture increases survival 557

Acupuncture (group 8 vs groups 7). Electro-acupuncture stimulation is significantly \( (P < 0.02) \) better than manual acupuncture treatment (group 6 vs group 7) and there is significantly \( (P < 0.05) \) higher survival with high-intensity treatment (group 2 vs group 3) than low intensity. However, there is no significant difference when comparing high-frequency with low-frequency electro-acupuncture treatment (groups vs group 6). The results also show that repeated electro-acupuncture treatments are significantly better \( (P < 0.02) \) than one single treatment (group 6 vs group 2). As for the time factor, post-operative treatment is significantly \( (P < 0.05) \) better than pre-operative treatment (group 2 vs group 1). The choice of post-operative day of treatment does not significantly influence the outcome (group 2 vs group 4).

The present results show that acupuncture treatment increases survival of ischaemic tissue in a musculocutaneous flap model in the rat. The highest flap survival was obtained when repeated post-operative electro-acupuncture was applied with high intensity. The flap survival was not significantly related to the frequency used.

Pre-treatment with anti-adrenergic drugs has been shown to increase survival of the musculocutaneous flap in the rat (Jonsson et al. 1975, Jurell & Jonsson 1976). This is interesting to note as activity in muscle afferent fibres may inhibit activity in sympathetic vasoconstrictor neurons through a complex reflex arrangement (Rowell 1981). It has been suggested that acupuncture induces analgesia by activation of type III muscle afferents (Wang et al. 1985). Some while ago it was shown that antidromic stimulation of sensory nerve fibres causes cutaneous vasodilatation (Hinsey & Gasser 1930). A release of the neuropeptides substance \( P \) and/or calcitonin gene-related peptide (CGRP) may be responsible for this effect (Lembeck & Gamse 1982, Couture & Cuello 1984, Brain & Williams 1985, Brain et al. 1985, Gamse & Saria 1985). It has recently been shown that post-operative treatment with CGRP at low molar doses increases the rat musculocutaneous flap survival to a rate comparable to the survival obtained with acupuncture treatment (Kjartansson & Dalsgaard 1987). The results of the present study are in line with previous reports of the effect of electrical nerve stimulation in experimental and clinical ischaemia (Kjartansson et al. 1988a, Lundeberg et al. 1988). As seen in the present study there was no significant difference between the day of treatment and result, and acupuncture was effective when applied post-operatively. This is of clinical interest since ischaemic conditions can be treated if and when signs of critical circulation occur and pre- and/or per-operative treatment is not needed as is the case with anti-adrenergic treatment. Further, the results of this study suggest that the effects of acupuncture on ischaemic pain may be at least partly due to effects on the peripheral circulation. The mechanism for this action is not known but it may be suggested that acupuncture activates afferent nerve fibres that interact with sympathetic vasoconstriction neurons and/or that acupuncture activates sensory nerve fibres to release vasodilatory compounds. The results indicate that acupuncture may be of importance for the treatment of clinical conditions with local ischaemia.

In conclusion, electro-acupuncture and manual acupuncture treatment markedly increase the survival of experimental musculocutaneous flaps in rats.

The skillful assistance of Ms Ulla Lindgren in typing the manuscript is gratefully acknowledged. This study was supported by grants from the Royal Swedish Academy of Sciences and Åke Wibergs Stiftelse. The present study was approved by the ethical committee of the Karolinska Institute.

REFERENCES


