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DELAYED HEALING OF EXPERIMENTAL FRACTURES IN THE DENERVATED LIMBS OF DOGS. CLINICAL AND RADIOLOGICAL STUDY

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Objective: Study the effect of denervation of the limbs on bone healing in dogs.

Design: Experimental humeral mid-shaft osteotomy and immobilisation by plates were performed in the right forelimbs of two groups of dogs. At the same time, total brachial plexus neurectomy was undertaken in animals of the first group. The second group was control. Clinical and radiological findings were recorded for a period of three months.

Results: Animals of the neurectomised group had complete paralysis of the right forelimbs and did not show complete radiological union after 90 days while the control group healed at 45 days.

Interpretation: Denervation significantly ($P < 0.05$) delayed bone union and retarded callus formation in experimental fracture.

Conclusion: Further studies required to understand the exact role of normal innervation of bone in fracture healing, and the effect of trauma on bone repair in paralytic limbs. Bahrain Med Bull 1996;18(1):

The effect of peripheral nerve lesions on callus formation is controversial. Thus while peripheral denervation is believed to delay healing and decrease the rate of callus formation of experimental fractures, rapid fracture union by bridging external callus has been demonstrated in denervated limbs of rats[1-6]. The callus produced in the latter condition was smaller, less dense, contained less collagenous matrix and less minerals with incomplete maturation of woven new bone than normally produced callus[7-10]. The same was also observed in the neurologically injured patients and those suffering from head injuries[4,12-18]. This study is designed to examine the effect of total brachial plexus neurectomy on experimental fracture healing in humerus of dogs.

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METHODS

The study was carried out at the Animal Research Center of the Medical College, King Saud University, Saudi Arabia, on 8 clinically healthy native breed dogs of both sex and aged 2-4 years and weighing 18-30 kg.

Experimental osteotomy and immobilization by the use of plate was performed in the right forelimbs of all dogs. The animals were classified into two groups;

group 1 (n=5) underwent denervation of brachial plexus in addition to osteotomy and group 2 (n=3) (control group) underwent osteotomy only.

The animals were anaesthesised with intramuscular injection of xylozin and Ketamine hydrochloride in a dose of one mg/kg and 10 mg/kg body weight respectively. Anaesthesia was maintained and continued by the use of thiopentone sodium. After tracheal intubation, ventilation was controlled by the use of an automatic ventilator.

The ventral roots of the last four cervical spinal nerves and that of the first thoracic forming the brachial plexus were dissected and neurectomised[19,20]. This produced flaccid paralytic limb.

The osteotomy was carried out through lateral longitudinal skin incision. The brachiocephalic muscle was reflected cranially and the brachialis muscle caudally. A complete mid-shaft transverse osteotomy was performed by an electrical surgical saw. The two humeral ends were then fixed and immobilised in their normal anatomical position by the use of six-holes dynamic compression plate (DCP) with a 6 cortices fixation in each segment. The surgical wound was then closed and the skin sutures were protected by the skin fold covering suture. Chloramphenicol was applied locally during the operation and systematically for 3 successive days after the operation as a protective measure against infection in a dose of 40 mg/kg body weight.

All the operated humeral shafts were examined radiologically immediately after the operation and 15, 30, 45, 60 and 90 days post-operatively. The used radiological exposure values were 50 kV and 5.0 mAs. Each radiograph was examined for the evidence of bone union and the presence of bridging callus in the osteotomy gap.

RESULTS

Clinical Observations

Two dogs from the neurectomised group died 48 hours post operatively. Skin wounds of all survived animals healed well by first intention.

Animals of the neurectomised group showed complete paralysis of the right forelimbs with complete absence of skin sensation and shortening of the operated limbs. The animals could not bear any weight on the neurectomised limbs which were raised from the ground with flexion of the elbow joint. The phalangeal joints were also flexed. The skin in front of the carpal joint was ulcerated, as this area was in contact with the ground.

On the other hand, all animals of the control group started to bear weight on the operated limbs 7-10 days post operatively. They could also walk normally without any signs of pain or limping 15-20 days after the operation.

Radiological Findings

The immediate postoperative radiographs of both groups showed accurate reduction of the bone ends which were fixed by the DCP with 6 cortices fixed at both ends of the osteotomy site (Fig 1). At 15 days after the operation, there was no radiological change at the osteotomy site in the neurectomised animals, while faint bridging was recognised in the animals of the control group. At 30 days post-operatively, early faint bridging was observed in two neurectomised animals. In the third neurectomised dog, there was no evidence of bridging or bony union. However, in the control group, the osteotomy gap was filled with callus with evidence of surrounding periosteal reaction (Fig 2). At 45 days the osteotomy gap was visible in all of the denervated dogs, while it was not visible with complete callus formation in the control animals. At 60 days there was faint bony formation at the osteotomy site in the neurectomised group while in the control group complete remodeling of the fracture site was observed (Fig 3). At 90 days there was no evidence of union in the neurectomised animals and the osteotomy line remained sharp throughout the whole three months (Fig.4).

DISCUSSION

This study demonstrates that bone union following experimental osteotomy was faster in normal unneurectomised dogs compared to the denervated animals. These results are in agreement with many investigators[1-6]. In contrast, other workers demonstrated rapid fracture healing by bridging callus in the denervated limbs of experimental rats than in the controls[7-10]. This observation was also noted in patients with spastic type of paralysis rather than a flaccid paralysis which occur following denervation.

In addition, the internal fixation used in this study is in accordance with the recommendation of "ASIF"[22] (Association for the Study of Internal Fixation). This include the application of the six holes DCP following anatomical reduction of the bone ends using three screws on each side holding six cortices.

Aro9 demonstrated that the callus formation in the denervated limbs was little, less dense and contained immature new bone and less collagenous matrix and minerals with less RNA to DNA ratio than the control. This could explain the importance of intact innervation for normal bone healing. However, the delayed fracture healing in the paralytic forelimbs of the neurectomised group in this study could also be partially attributed to the decreased loading or the absence of weight bearing factor on the fracture healing as explained by Sarmiento et al and other workers[23-26]. The positive effect of these forces is to increase periosteal bone formation at the fracture site, increased blood flow and also bone remodelling[23-26]. Meanwhile, micromovements of the paralytic limbs occurred during the animals movements in their free boxes may also played some positive effect. Goodship and Kenwright[27] and Wallace et al[28] manifested that axial micromovement at the fracture site has been shown to promote and enhance healing of experimental fractures. This has also been proved clinically by Kenwright et al[29]. It would have been ideal to keep the control group non weight bearing for the whole period of the study, but that was practically impossible.

CONCLUSION

Denervation delayed bone healing in experimental fracture. Further studies supported by histological examination and using large number of animals are essential. The exact role of the normal innervation of bone in fracture healing, and the effect of trauma on bone repair in paralytic limbs need also to be investigated.

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