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THE EFFECT OF CRUSH INJURY TO THE SKIN ON HEALING OF FRACTURE OF THE SHAFT OF THE TIBIA IN DOGS

By

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INTRODUCTION

In a clinical investigation of fractures of the shaft of the tibia (*Bauer, Edwards & Widmark 1962*) it was found that the incidence of infection, delayed union and poor end results was directly related to the etiology of the fractures: the results were uniformly good in fractures caused by moderate, indirect violence and were relatively poor in fractures caused by severe, direct violence. These results were interpreted to suggest that the prognosis in fractures of the shaft of the tibia was related more to the severity of soft tissue damage than to the bone injury.

This hypothesis was tested in a prospective series of the shaft of the tibia in man: special attention was given to the management of the skin injury. In comparison with an earlier control series of fractures this policy resulted in a lower incidence of necrosis of the skin and osteomyelitis, associated with improved final status of the fractures (*Edwards 1965*).

The results of the clinical investigation were confirmed by the findings in a series of experimental fractures of the tibia in dogs reported here.

MATERIAL AND METHODS

Both tibia were fractured in each of 15 mongrel dogs, weighing about 20 kg. The fractures were produced by a blow first to one and then the

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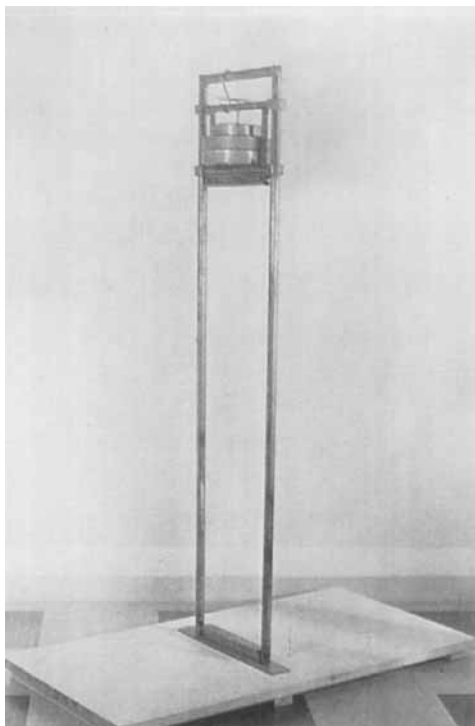


Fig. 1.
Fracture device.

other leg by means of a guillotine type hammer with removable weights (Fig. 1). The force of these blows varied between 11 and 23 kgf, but in each animal the energy delivered to one leg was equal to that delivered to the other leg. Prior to fracture the animals were anesthetized by intravenous injection of 0.5 ml 6 per cent Nembutal per kg body weight, both legs were shaved, and the skin washed with soap, water, and Bensalkon. On the control side the skin was first incised for about 10 cm along the antero-medial surface and dissected free from the tibia. In this way the control tibia received a direct blow from the hammer and the experimental tibia received a blow through the skin. All fractures were of the comminuted type, moderately displaced (Fig. 2), associated on the experimental side with a skin wound 1–3 cm in length. Immediately after fracture, the wound on the experimental side and the incision on the control side were sutured, and both lower extremities were placed in toe to groin circular plaster bandages.



Fig. 2.

Dog no. 11, showing a typical fracture; comminuted and moderately displaced.

After fracture new plaster bandages were applied under anaesthesia to both the control and experimental extremities at intervals of 2 weeks or less. The incidence of necrosis of the skin and of osteomyelitis, and the time of clinical healing of the fractures were recorded.

RESULTS

A. Complications

In 12 of the 15 dogs, necrosis of the skin and/or osteomyelitis occurred (Fig. 3). These complications were found only on the experimental extremity, and never on the control extremity.

Three dogs, all with deep necrosis of the skin (exposure of bone), died 3 weeks after fracture. Two of these died during anaesthesia for the re-application of plaster, and one for unknown reasons.

B. Healing Time

In the 12 dogs that survived until both fractures of the tibia had healed, the healing time was shorter on the control than on the experi-

mental side (Table 1). The healing time on the control side did not differ much between animals: 4 weeks or less in 10 animals, and all 12 control fractures healed within 6 weeks.

The experimental side fractures were still un-united in 3 dogs which were sacrificed 13, 14 and 22 weeks after fracture. The healing times in the other 9 experimental fractures ranged from 6 to 16 weeks with a mean of about 9 weeks.

TABLE 1
Incidence of Complications and Time for Clinical Union in Fractures of the Shaft of the Tibia in Dogs.

Dog	Body Wt. (kg)	Fracture force (kgf.)	Complications		Healing time (weeks)	
			Necrosis of the skin	Osteomyelitis	Control	Experimental
1	27	11	+	—	4	>22
2	16	10	++	—	4	8
3	24	14	—	—	4	14
4	18	14	+	—	4	6
5	14	14	+	—	4	>14
6	18	23	—	—	6	8
7	23	23	—	—	4	8
8	18	23	++	—	6	12
9	19	23	+	—	4	6
10	18	23	+	—	4	8
11	13	23	++	—	4	8
12	23	23	++	++	3	>13
13	19	11	++	?	—	×
14	25	14	++	?	6	×
15	20	23	++	?	6	×

× Dog died 3 weeks after fracture.

DISCUSSION

Infection of fractures of the tibia in man is a complication which may cause non-union or, at best, prolongation of the healing time (*Watson-Jones & Collart 1943, Nicoll 1964, Edwards 1965*). The latter author has emphasized the association of skin necrosis with osteomyelitis.

In the surviving dogs reported here 9 of the 12 fractures on the experimental side were associated with necrosis of the skin. In 4 of those the necrosis was so deep that the fracture was exposed. However, only one of these developed osteomyelitis with fistula formation. This observation confirms the fact that the dog is less susceptible to infection of bone than is man. It was observed that skin defects were rapidly

*Fig. 3.*

Fig. 3. Dog no. 11. Deep necrosis of the skin with exposure of the fracture.

*Fig. 4.*

Fig. 4. Dog no. 11. 3 weeks later. The skin defect is covered with granulation tissue.

covered with granulation tissue (Fig. 3 and 4). An alternative possibility would be that the dogs harbored an infection in the slow-healing fractures of such low grade or atypical type that criteria for the diagnosis osteomyelitis were not met.

The association between a crushing blow to the lower leg, necrosis of the skin, and delayed or non-union of fracture of the shaft of the tibia was firmly established in the experiment reported here. In the absence of signs of severe infection it is not possible to explain the cause of this association.

S U M M A R Y

Bilateral fractures of the shaft of the tibia were produced in 15 dogs on one side with and on the other side without production of crush injury to the skin. The initial skin injury developed into necrosis of the skin in 12 dogs, and into osteomyelitis in one. In all 12 dogs surviving the initial phase of the experiment, the time for healing of the fractures was markedly prolonged in 9 and probably significantly prolonged in all. These data are interpreted as evidence of a causal relationship between skin injury and poor healing of fractures of the shaft of the tibia as observed in man.

RESUME

Des fractures bilatérales du corps du tibia ont été provoquées chez 15 chiens, d'un côté avec lésion de la peau au choc, de l'autre côté, sans lésion. Il s'est développé une nécrose de l'épiderme blessé chez les 12 chiens et une ostéomyélite chez un. Chez tous les 12 chiens qui ont survécu à la phase initiale de l'expérience, la durée de guérison des fractures a été beaucoup plus prolongée chez 9 et probablement nettement prolongée chez tous. Ces données sont interprétées comme la preuve d'une relation causale entre la lésion de l'épiderme et la mauvaise guérison des fractures du corps du tibia observée chez l'homme.

ZUSAMMENFASSUNG

Doppelseitige Brüche des Schaftes der Tibia wurden bei 15 Hunden, auf einer Seite mit und auf der anderen Seite ohne Quetschungsschäden der Haut, erzeugt. Die ursprüngliche Hautbeschädigung entwickelte sich zu einer Hautnekrose bei 12 Hunden und zu einer Osteomyelitis bei einem. Bei allen 12 Hunden, die die Anfangsphase des Experimentes überlebten, war die Heilungszeit der Brüche ausgesprochen verlängert bei 9 und wahrscheinlich bedeutend verlängert bei allen. Diese Daten werden als ein Beweis des ursächlichen Zusammenhanges zwischen Hautbeschädigung und schlechter Heilungstendenz von Schaftbrüchen der Tibia, wie sie am Menschen zu beobachten ist, angesehen.

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