wound healing - a reappraisal

brian cronin

part two † towards super-normal wound healing

It has been suggested that surgeons will never be able to compete with the farrier who successfully sewed back into place, with the aid of fresh sprigs and laurel shoots, the entire rear portion of the Lithuanian horse which the intrepid Baron Boris von Müncausen had just ridden under a falling portcullis. (18).

The writer, it is hoped, will be forgiven his enthusiasms when he declines to agree with the above statement.

It is now feasible to restore an amputated hand back to its owner with successful functional results. Examples of noses and ears being regrafted back to their original state after amputation are now quite commonplace. The meteoric boost that Professor Christian Barnard initiated in December 1967 in the form of the first attempt at human cardiac transplantation is now famous (or notorious!). Whichever way it is regarded, it was certainly a revolution. Kidney transplantations are now fairly routine procedures in some hospitals (26 such operations were performed last year in the Cardiff Royal Infirmary), and pioneering attempts are being made at liver transplants.

The role of "spare part surgery" has come increasingly to the fore in the last five years. Longmore (19) states that "Medicine has always operated in two sectors: Therapeutics and Surgery, the former being largely concerned with external attack and the latter with internal breakdown."

Paradoxically, the increasing success of Therapeutics has thrown an ever-increasing burden on Surgery. People who might have died from a communicable disease before their third decade are now living on into middle and old age, thus becoming candidates for degenerative diseases and disorders. Surgeons can thus look forward to more operations on individuals in whom it is well recognised that wound healing powers are diminishing. Thus the need for better methods of wound healing is imperative.

Bullough argues that since hundreds of millions of years of evolution lie behind the organization of any modern animal, and a strong selective advantage must have been enjoyed by any individual with an unusually effective wound healing capacity, it is possible that in any modern animal the mechanism of wound healing and tissue regeneration may already have approached its maximum possible efficiency. From this conclusion he argues that if it is so, then the only practical treatment of wounds must be to ensure that no adverse circumstances such as infection are allowed to impede the natural processes.

So far only the "Hows" (or proximate causes) of wound healing have been discussed.

THE PHILOSOPHY OF WOUND HEALING

Why does wound healing occur?

This question is asked by Spilsbury (20).

When one considers that there is an average of one new minor wound a week in any individual, *i.e. 3,500 or more* in a lifespan of 70 years, then there is scarcely any doubt that wound healing plays an important part in the life and survival of animals.

There can be no survival without repair. However, the power of repair bears an inverse relationship to the complexity of the organism (21). (See Figure 6).

The reason is probably that the degree of morphological and particularly histological differentiation is dircetly related to the grade so that the dedifferentiation necessary as a prelude to regeneration becomes increasingly difficult or uneconomic.

The Second Law of Thermodynamics and its suggested relevance to wound healing:—

The sea cucumber, Holothuria, clings to tropical reefs and lives by filtering large amounts of sea water through its alimentary tract, and

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ingesting organic matter from it. When frightened, it has the habit of ejecting its whole alimentary tract into the sea water as a sort of smoke screen. Thereafter, it regenerates a new alimentary tract without apparent difficulty. By contrast, homo sapiens has great difficulty in repairing a perforated duodenal ulcer.

From such examples Schrödinger attempts to draw on the Second Law of Thermodynamics to try to explain these phenomena in physical terms. The Second Law of Thermodynamics states that in any physical change, free energy declines and entropy (energy unavailable for use) increases. Thus entropy can be thought of as the measure of the chaos or randomness of a system.

In the above example of Holothuria versus man's weak regenerative power, the Holothuria may be regarded, according to Schrödinger's analogy, as having a **low** entropy, while man has a **high** entropy.

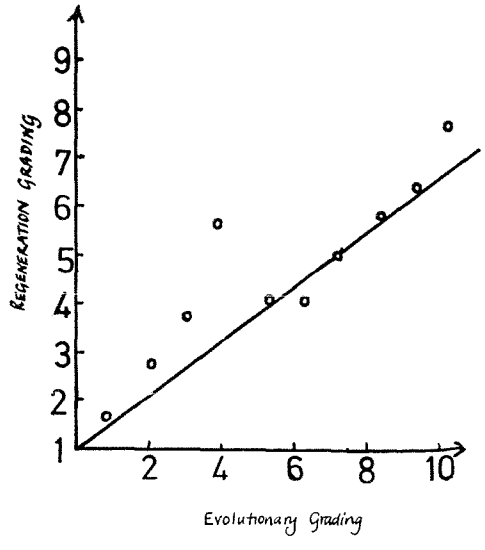
When examining wound healing we are observing mechanisms evolved over millions of years, which are part of the powers to resist entropy. It may be pertinent to note that some authors think in terms of the Second Law of Thermodynamics as being applicable in the case of man only after death.

Why should the process of regeneration of antlers in stage enter into the field of consideration in human wound healing?

Stags' antlers are covered by velvet until fully grown and the whole vast area of skin is regenerated from a small area of tissue which healed over the scar left when the previous year's antlers were shed. (22). In the growing antler it has been shown by Billingham that the hair follicles form *de novo*, a very rare event in other mammals and a fact of much interest to embryologists. If wound healing is regarded as a proximate cause of antler growth, then one might speculate that the final cause of the evolution of antlers might have involved modification of wound healing in structures especially vulnerable to injury. Deer regenerate skin over the metatarsals in the same makeshift manner as in other mammals. The reason why antlers regenerate in such a way could lead to the introduction of completely new concepts regarding wounds and their healing.

"Mind-bending" breakthroughs in the field of Soviet research, led by Professor Lev Polzhaev have revealed a completely new method of increasing the powers of repair in man. He suggests that it is not necessarily so that man's capacity to restore lost tissues and damaged organs is severely restricted. Ethical and moral problems introduced by cardiac transplants may become redundant, should the intriguing possibility come to fruition (23) of causing regeneration of heart muscle to replace that lost through disease.

FIGURE 6



Evolutionary Regeneration grading

1. Primitive Diploblastica	1. Regenerates whole body from mass of dissociated cells
2. Diploplastica with Nervous System	2. Regenerates from small fragments.
3. Mesenchymatous Triploblastica.	3. Regenerates whole body from large fragments only
4. Pseudo Coelomata	4. Regenerates limbs and similar portions of body.
5. Coelomata Triploblastica.	5. Regenerates whole limbs etc. only in special cases
6. Coelomates with Oligomeric Segmentation	6. Can only regenerate fractions smaller than whole limbs.
7. Metameric Coelomates.	7. Repairs only the skin, bones and other tissues.
8. Limbed Metameric Coelomata.	8. Close wounds but do not regenerate tissues.
9. Amphibious, limbed Metameric Coelomata	
10. Terrestial limbed Metameric Coelomata	
11. Homoiothermic Terrestrials	

Polezhaev's experiments began while he was still a student. He amputed the hind feet of tadpoles at a late stage in development, damaging one stump with a needle and leaving an undamaged stump as a control. Repeated trauma seemed to produce a dedifferentiation of tissues and a new normal limb resulted, whereas the control stump healed by a normal process of scarification.

He claims to have caused regeneration in cranial bone of dogs. Holes were made in the skull and he used bone dust to stimulate regeneration. Complete regeneration of bone occurred, he claims, in every case, provided that the periosteum and the underlying dura mater were left intact. Regeneration of filled teeth can be obtained by packing the cavity in the tooth with dentine dust (treated with pennicillin) and capping it with temporary filling.

The most astounding claim he makes is that heart muscle can be made to regenerate by using "regeneration stimulators". He even claims to have caused cellular regeneration and reorganization of neurones within the brain!

I wrote to Professor Polezhaev some months ago asking for details of his work, but I am still awaiting a reply.

part three
some personal observations

An understanding of epithelial closure in primary suture wounds led Gillman some years ago to propose a none-suture closure of the skin, a method first practised by the Ancient Egyptians. Gillman has discussed the advantages of the use of adhesive tape (Steristrips) at length in Archives of Surgery 1966 (Dec.). Briefly, these are as follows:—

1. Non-suture closure of the skin avoids necrosis of the wound edges and underlying tissue by sutures which may have been tied too tightly. They eliminate the problem of stitch abcesses.
2. They permit some slight swelling of the wound without an increase in tension of sutures.
3. Steristrips may be left in situ for as long as two to three weeks, thus providing strong support for the wound long after it would be necessary to remove the sutures. Indeed Gillman recommends that the tapes be allowed to remain in situ until they fall off spontaneously.

The use of non-suture closure as a means of keeping skin grafts applied to burns has already been reported locally. (23). It has also been found feasible and satisfactory even in the majority of thoracotomies, as shown by Shepherd. (24). Gibson and Poate (26) outline briefly the use of steristrips in relation to plastic surgery and suggest that their use represents an important advance in the search for a technique that will produce the "invisible scar".

CASE 1.

The use of steristrips as a means of temporary closure is helped whilst the patient is awaiting reduction for an underlying fracture. As can be seen, the effect on the patient is not the usual apprehension which attends the preparation of syringes and suture materials!

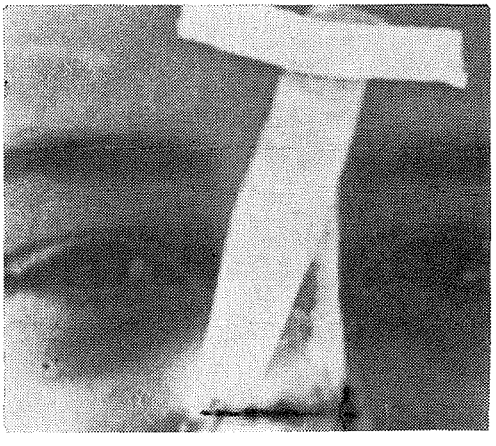


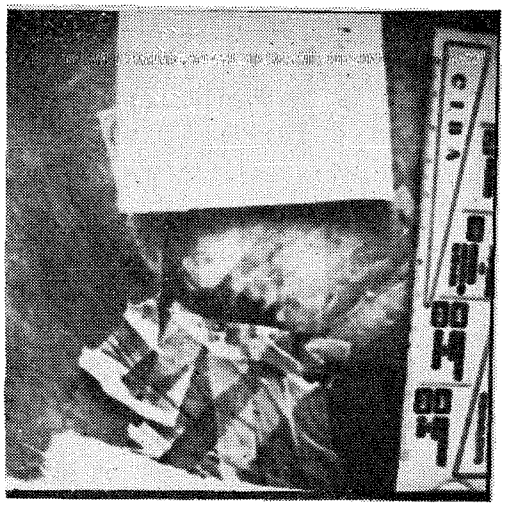
Fig. 7. **(Case 1).**

CASE 2.

The patient was a 38 year old female (fig. 8).

Grossfeld has shown from the results of 44 patients that delayed primary wound closure significantly reduces the incidence of wound infection (2.3% incidence compared with 34.1% incidence with closure performed at initial operation.) (27).

Nevertheless, this patient with an appendicectomy wound closed by the use of steristrips at operation, showed no changes suggestive of infection. There was no dehiscence and no spikes of temperature noted in the temperature chart. She was extremely pleased with the resultant hair-line scar.



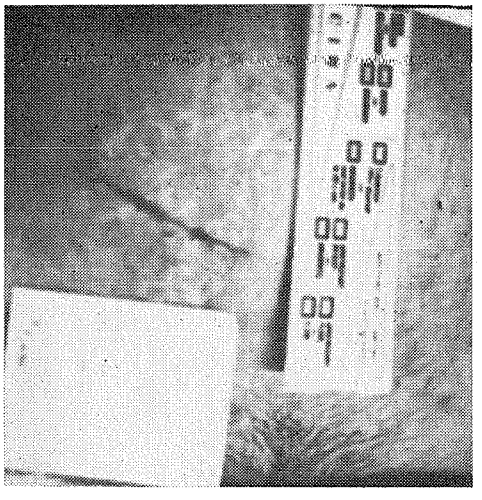
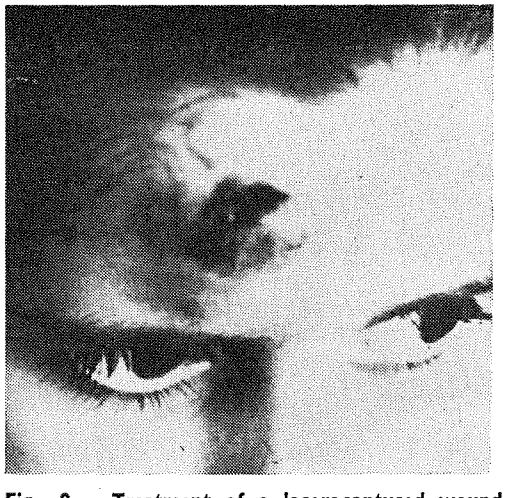


Fig. 8. Female 38 years appendicectomy scar. **(Case 2).**

CASE 3.

A young lad arrived at the Casualty Department, accompanied by his parents and several relatives, all looking very worried. He had a laacerocontused wound on his forehead about an inch in length. Inspection revealed no foreign bodies and bleeding had stopped. After cleansing, the edges of the wound were coapted and held in place by steristrips. The whole procedure took no more than a couple of minutes and the result was excellent (Casualty officer's appraisal at a later date.) The anxiety of child, parents and relatives was dramatically removed. (fig. 9).



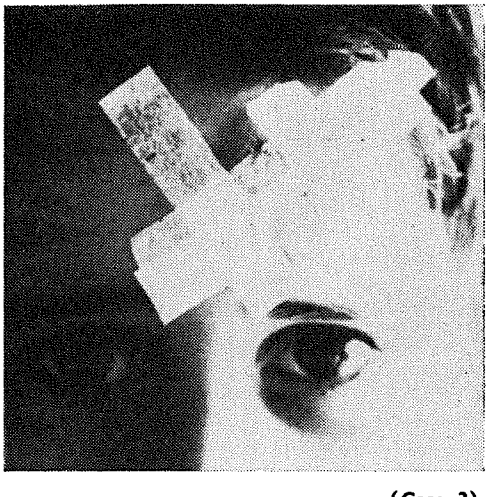


Fig. 9. Treatment of a lacerocontused wound. **(Case 3).**

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CASE 4.

The patient was a 60 year old male, (A.F.), suffering discomfort from a bilateral inguinal hernia. His state of health was otherwise normal. The hernia on the right side was sutured normally, the hernia on the left side was taped with steristrip. When the patient had his sutures removed on the 8th day there was a spike of temperature (99 F). There was a marked difference in the cosmetic appearance of the taped side compared with the sutured side! Unfortunately the patient did not reappear at Outpatient Department for the resultant scars to be compared (see fig.10).

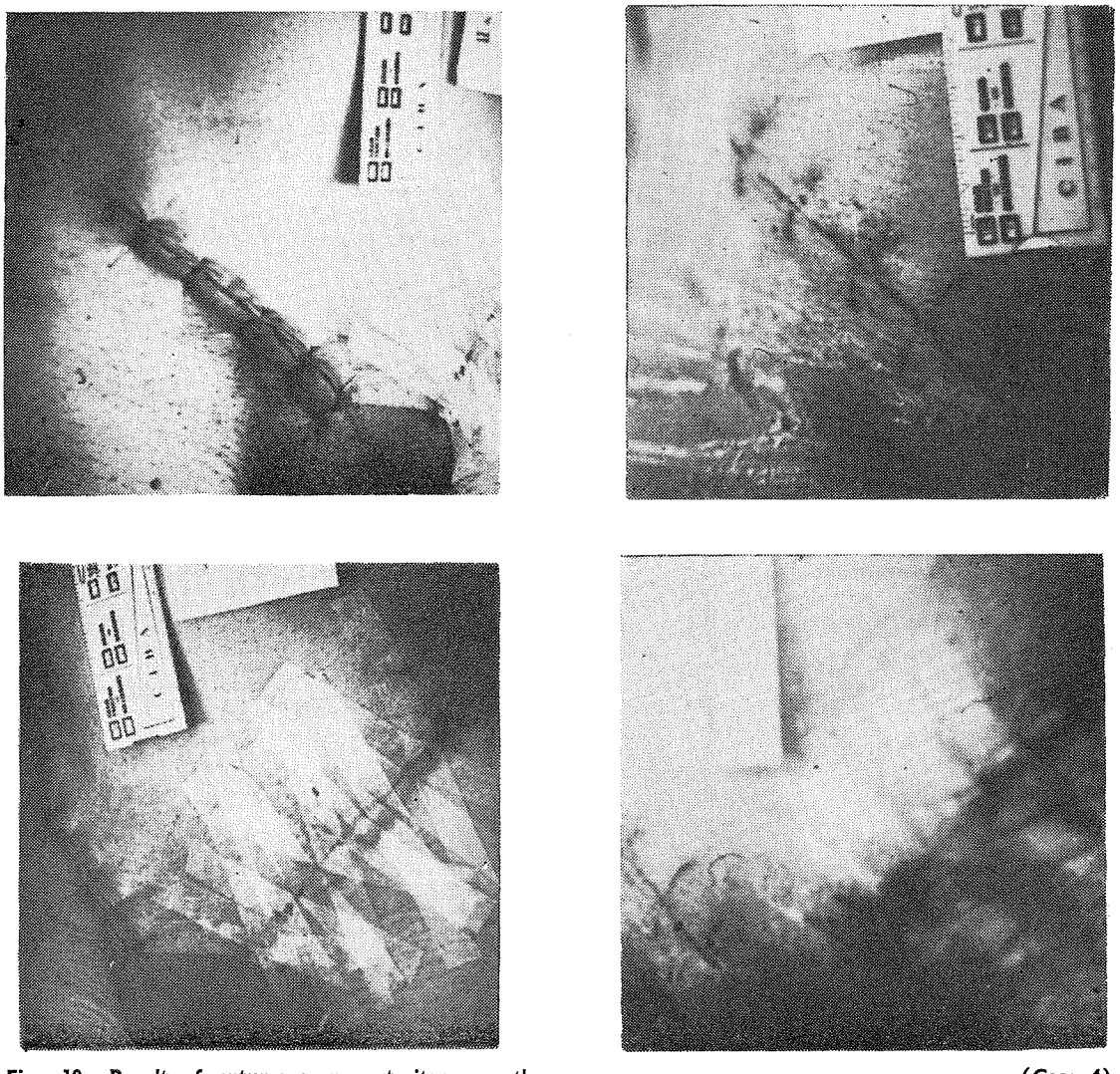

Fig. 10. Result of sutures versus steritape on the same individual, before and after 15 days. (Case 4).

From these examples it seems that closure by means of non-suture materials plays a valuable role in the management and treatment of wounds.