

Professor D M Douglas
(*Department of Surgery,*
University of Dundee)

Wound Healing

The quantitative study of gain of wound strength began with the work of Harvey in Yale in 1926. He and Howes showed that a wound gained strength in the form of a sigmoid curve in which there is an early lag period lasting three or four days, a second period of rapid gain of strength lasting about three weeks, and then a slow period of increasing strength, the duration of which is not known. Correlation between this curve and the build-up of collagen in wounds was demonstrated by Dunphy and his co-workers in Portland, Oregon. Confirmatory studies have been carried out by Sandblom in Lund and by the author in Dundee. The only factors which have been shown positively to modify this healing curve have been vitamin C deficiency and protein deficiency and the only way to accelerate it is by preliminary wounding. During the past two years in Dundee we have been working on the later stages of wound healing and have found that skin wounds both in animals and in man remain weak for many years. Thus in guinea-pigs skin wounds are still only about 30% of their original strength at the end of one year and in man, wounds at the end of three years have still regained only about 50% of their original strength. Even at the end of fourteen years a deficiency exists. It is likely, therefore, that incised wounds produce a permanent weakness and that restitution to previous strength does not occur.

The cause of this failure to regain normal strength is unknown but our studies in Dundee suggest that it is due to failure of aggregation of fibre collagen into normal-sized bundles. Thus the average size of collagen bundles in healing wounds at sixty days is between 5 and 10 μ m whereas normal dermal collagen has a diameter of about 20 μ m. Coinciding with this is a difference in birefringence; dermal collagen is quite strongly birefringent, wound collagen fails to rotate polarized light.

In terms of practical wound management it is wise to take great care with the repair of the strong collagen layers in the abdominal wall. Thus the rectus sheaths in the paramedian incisions and muscle sheaths in the lateral incisions should be approximated by very many fine sutures of unabsorbable material. Interrupted and not continuous sutures should be used. Finally, it is wise to realize that in obese and bronchitic patients an incised wound gives rise to a serious weakness in

the abdominal wall in which dehiscence or herniation may occur, and in nonmalignant conditions operation should be avoided in this group whenever possible.

[For a fuller account of this work see Douglas *et al.* (1969).]

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Mr Robert E Horton and
Mr Paul C Smith
(*United Bristol Hospitals*)

Incisional Hernia

Operations for incisional hernia fall into three categories:

- (1) Operations in which direct suture of the defect is done after excision of the sac. In many cases some form of overlap of the edges is made after the fashion of the Mayo operation for umbilical hernia.
- (2) Defects dealt with by insertion of a prosthesis which is sutured round the defect. Materials which have been used include skin, fascia lata, external oblique aponeurosis, flaps of rectus sheath, stainless steel mesh, tantalum gauze and Mersilene gauze. If equally good results can be obtained without the use of foreign materials these should be avoided as they carry the risk of rejection and formation of a discharging sinus.
- (3) The keel operation, first performed by Maingot (1954). In this the sac is cleaned but not opened and then invaginated with several layers of longitudinally running sutures. The final row of sutures brings the muscles together so that the whole of the sac is invaginated and normal tissues approximated. Defects up to 6 inches (15 cm) can be closed if sufficient lateral mobilization is done. This is an important observation from the point of view of operative technique and it is possible because of the pathology of incisional hernia. Little or no tissue loss takes place but the hernia results from stretching of the scar.

During 1960–63 36 operations for incisional hernia were done in the general surgical theatres

Table 1
Types of repair employed in 36 cases of incisional hernia

Operation	Total cases	Recurrences
Catgut suture	4	4
Thread or nylon suture	18	5
Mersilene gauze	5	2
Rectus flaps	2	0
Nylon darn	3	3
Tantalum gauze	1	1
Keel operation	3	1

of the Bristol Royal Infirmary out of a total of more than 15,000. When these cases were examined 5-8 years later it was found that 16 (44%) had recurred. More than half the patients with recurrent hernias were pleased with the result and did not know that a recurrence had taken place.

There were insufficient numbers of any particular operation for an assessment of their relative merits to be made, except that direct repair with catgut (4 recurrences out of 4) and the nylon darn operation (3 recurrences out of 3) were clearly unsatisfactory (Table 1).

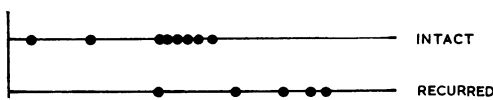
When the results were studied in more detail it was found that obesity was outstandingly blame-worthy in the causation of recurrence. All the female patients treated by direct suture with thread or braided nylon and who weighed more

than 11½ stone (73 kg) had a recurrence. Only one recurrence took place among those who weighed less than 11 stone (70 kg) (Fig 1A).

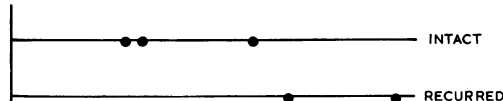
A similar result was obtained in the female patients whose hernias were repaired with Mersilene gauze. Three patients weighing under 12 stone (76 kg) have not had a recurrence but two others weighing 13 and 15½ stone (82-99 kg) have recurrent hernias (Fig 1B).

In men the results are different, probably because men have stronger abdominal muscles and fasciæ. Here weight does not seem to be a critical factor in recurrence (Fig 1C). When the operation for incisional hernia is confined to men and women weighing less than 11½ stone (73 kg) a reasonable long-term result can be expected with any operation which is well done, and when heavy women are excluded from our figures the recurrence rate is about 5%. While operation may be justifiably advised in many cases, women over 11½ stone (73 kg) should be treated with a corset unless they are prepared to lose weight to this level.

A THREAD OR NYLON . WOMEN



B MERSILENE . WOMEN



C THREAD OR NYLON . MEN

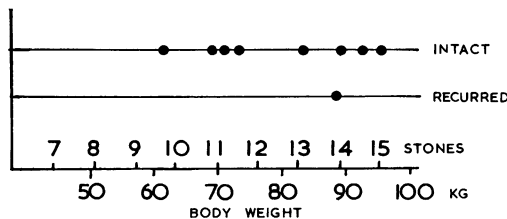


Fig 1 Results of operation for incisional hernia in 36 patients. The top line of each pair shows the weight of the patients whose hernias have not recurred following operation. The bottom line shows the weight of patients whose hernias have recurred

Burst Abdomen

The type of patient who develops a burst abdomen is well known. In our experience 50% of the patients were more than 60 years of age and 50% had malignant disease, often advanced and incurable. The patient on long-term steroid therapy is also at risk and may burst the abdomen about the twelfth day, soon after the removal of tension sutures. Patients on steroid therapy should not have tension sutures removed before the twenty-first day.

Elderly patients with malignant disease are a particular problem as they are so prone to this complication. Two layers of catgut with conventional tension sutures placed after catgut closure of the peritoneum was the most common type of closure employed. In the case known to be prone to burst abdomen non-absorbable sutures should be used, or tension sutures placed through all layers before closure of the peritoneum. Burst abdomen can be prevented by this technique provided the tension sutures are placed 1 inch (2.5 cm) apart.

Acknowledgment: It is a pleasure to record our gratitude to our colleagues on the staff of the Bristol Royal Infirmary for allowing us to review their cases.

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Mr H H G Eastcott (*London*) said that lateral muscle-cutting incisions were generally to be preferred for operations upon structures other than those in the mid-line; in fact almost the only absolute indication for median and paramedian incisions was when the lesion lay either deep in the pelvis or near the diaphragmatic hiatus. In most other cases where the object of surgery was fairly certainly located away from the mid-line – e.g. the gall-bladder and its ducts, the appendix or neoplastic cæcal mass, or the spleen – a good exposure could nearly always be obtained without lateral retraction and with little disturbance to the central, ileus-producing region by placing the muscle cut from the flank inwards, either up, across or downwards according to the level of the lesion.

In dealing with some 400 cases requiring reconstruction of the aorta and iliac arteries he had found that lateral extraperitoneal exposure had real advantages where the iliac condition was unilateral, particularly when the aorta was normal above the inferior mesenteric artery, and where the external iliac was diseased: this was a really difficult segment to reach via the median transperitoneal route. The latter also gave poor access to the lumbar sympathetic chains, particularly the right, whereas the lateral extraperitoneal exposure offered a perfect view on either side. When central longitudinal incisions had to be used – as in most cases of abdominal aortic aneurysm – he had found almost consistently good wound healing with the use of deep tension sutures tied over a long gauze roll, having repaired the rectus sheath with 34 gauge monofilament stainless steel wire.

Mr George Qvist (*Royal Free Hospital, London*) said that transverse incisions had a sounder physiological basis than vertical ones. The upper abdomen expanded laterally on inspiration and no doubt the fibrous intersections of the recti helped to keep these muscles in correct alignment, so that division of the intersections was probably an important cause of wound rupture and hernia after paramedian incisions. He had observed less trouble with vertical incisions in thin, old, weakly patients with little chest expansion than in young muscular individuals with powerful respiratory movements.

He considered the grid-iron incision a most inadequate approach for appendicectomy. Incidentally, this incision had first been described by Lewis Linn McArthur, but nomenclature had

probably been confused by McBurney's point (*see* McArthur S W, 1937, *Surg. Gynec. Obstet.* 65, 715).

The Weir incision, which was a type of transverse Battle incision, had many advantages and if necessary could be extended medially across the abdomen like a Pfannenstiel incision.

He had found the keel operation disappointing, and it was liable to recurrence because in some cases the peritoneal sac of the hernia became fused with the anterior surface of the muscle layer and therefore part of the sac was not obliterated by this method of invagination.

Mr Norman C Tanner (*London*) said that about twenty years ago he had started to use a mid-epigastric incision for upper abdominal work and closed the wound with two layers of catgut. On reviewing the patients about a year later, it had been seen that most of them were bulging at the site of the incision and so he reverted to the paramedian.

He felt that the mid-epigastric incision had something to commend it in so far as there was very little bleeding, very little tissue dissection and very little chance of hæmatoma formation. Consequently there should be a diminished chance of wound infection. Thus they had again reverted to the mid-epigastric incision, closing the deep layer with catgut and the superficial layer with continuous monofilament nylon reinforced with three or four interrupted monofilament nylon sutures. Monofilament nylon had the advantage that even if infection did take place, the wound might heal without the nylon having to be removed.

This had been free from trouble so far, with no hæmatomas, no deep infections and the wounds seemed to be holding extremely well when reviewed later.

Mr Guy Blackburn (*London*) said that the practice of closing the abdomen without suturing the peritoneal layer now seemed to have some adherents and he wondered what justification there was for it. Wound dehiscence, when it occurred, was always complete and never partial, and conservative management only replaced simple resuture by repair of the incisional hernia, which was more difficult.