as they were based on the results of a single meal of iron-fortified bread given to normal subjects.

The results of the experiment reported here give no evidence that additional fortification of flour is of therapeutic value; they also raise doubts about the value of the present level of fortification with ferrum redactum in this country.

Summary

Bread made from flour fortified with 60 mg. of ferrum redactum per 100 g. of flour was given for six months to two groups of 53 and 55 female patients in long-stay units of a mental hospital. Each patient received about 80 mg. of elemental iron per day. One group was given a vitamin C supplement twice a day for the last two months of the trial. A further group of 52 patients received the same total amount of elemental iron in tablet form as ferrous gluconate, and another group of 99 patients received no iron therapy. All groups were comparable with regard to age and haemoglobin level at the commencement of the trial.

No significant (at $P < 0.05$) increase in mean haemoglobin level was experienced by either group given fortified bread, but the group given tablets of ferrous gluconate did experience a significant mean increase. Patients with an initial haemoglobin level of less than 12.5 g./100 ml. in the group given fortified bread but no vitamin C experienced a significant increase in mean haemoglobin, but this increase was almost identical with that experienced by comparable patients in the control group. The patients with lower initial haemoglobin levels who received ferrous gluconate showed a significant mean increase of 1.60 ± 0.30 g. over the six months, which was significantly in excess of corresponding changes in all other similar patients.

These results are discussed and the therapeutic value of fortification of flour with ferrum redactum at a high level is considered; the relevance of the findings to the present statutory fortification of flour is indicated.

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CLOSURE OF THE INGUINAL CANAL IN TREATMENT OF HERNIA

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Removal of the hernial sac up to its neck, and closure of the opening or defect in the parietes, constitute the twin prongs of surgical attack on abdominal hernia. It appears surprising, therefore, that surgeons have preferred to compromise these basic principles in the treatment of inguinal hernia. The majority of procedures in current use leave room for the emergence of the cord, and, by not closing the inguinal canal, permit the risk of recurrence. The review below is a clinical study of 103 cases of inguinal hernia treated by closure of the inguinal canal, and is a resurrection of an earlier and less successful experiment carried out in America by Burdick and Higinbotham (1935). The stimulus to reassessment came from a limited reappraisal made by Bodhe (1959), in India, and the present study, while confirming many of his clinical findings, also attempts to explain some of the factors which contribute to a satisfactory result.

Selection of Cases

Of the 103 cases, three required orchidectomy for abdominal testis, haematocele, and testicular tumour respectively; in these, closure of the canal was employed incidentally in the repair of associated inguinal hernia. Deliberate closure of the inguinal canal after excision of the cord was performed in 100 cases of inguinal hernia. Unless a subject was already a parent, with one or more children, he was not thought suitable for this procedure. In a country where marriage is early and the reproductive rate high, the possibility of reduced fertility was regarded by many patients as an inducement to co-operate in this experiment. With very few exceptions those selected for this procedure were over 35 years old, the large majority being well over 50. Table I shows the age distribution, in decades. (The two patients below 30 were operated upon for large recurrent hernia. In the third decade, only four patients were less than 35 years old.)

The hernias chosen for this procedure were those generally regarded as unfavourable—large indirect hernias of long standing, recurrent hernias, sliding hernias, and combined (pantaloon) hernias. Large direct hernias were also included where it was thought that a more effective repair could be obtained by this method. Table II shows the relative incidence of the various types. During the period in question 297 cases of inguinal hernia were seen, including 37 bilateral cases.

TABLE I.—Distribution of Cases According to Age

Age	Below 30	30-39	40-49	50-59	60+
No. of cases	2	23	10	20	45

TABLE II.—Incidence of Various Types of Hernia

Indirect, including scrotal	51
Direct	33
Pantaloon	5
Sliding	4
Recurrent	7

Surgical Technique

The incision is made in the line of the skin crease, and the inguinal canal is entered by division of the

external oblique aponeurosis. The hernial sac is isolated and freed, and its contents are reduced. The sac is closed at its neck and the redundant portion is excised. In scrotal hernias the sac is transected at the top of the scrotum and its lower (scrotal) portion is left untouched; the upper portion is dealt with as described above. The cord, with the vas deferens, its vessels, and its coverings, is doubly ligated at the internal and external rings, and the intervening intracanalicular segment is excised. Both cut ends usually retract away from the operating field, although occasionally they may require to be gently pushed aside. The posterior wall of the inguinal canal is reinforced by suture of the conjoint tendon to the inguinal ligament as in a Bassini repair. The inguinal canal is obliterated by sutures which pick up the anterior surface of the conjoint tendon when the external oblique is repaired. Often it is possible to obtain additional buttressing of the anterior wall by overlapping the external oblique aponeurosis. Particular care is taken over the placing of stitches at each end of the repair—at the sites which mark the abdominal rings. Except for suture of the skin, where monofilament nylon is used, absorbable chromicized catgut is used throughout.

Antibiotics are not used routinely. In this series only three cases received them—two for post-operative chest infections and the third because of the development of an extensive retroperitoneal haematoma (see below).

Pethidine or morphine was given eight-hourly for the first 24 hours after operation. Aspirin or compound codeine tablets were found to be adequate for controlling pain thereafter. Early mobilization was encouraged as it aids self-confidence and optimism. The average stay in hospital was 12 days.

Complications

Unfortunately there was one death in this series. It occurred suddenly in a patient aged 50, on the fourth day after operation, while he was ambulant. Post-mortem examination revealed a subarachnoid haemorrhage from a ruptured berry aneurysm of the middle cerebral artery.

Scrotal haematoma formation occurred in five cases. Two of these required aspiration, while the other three responded to the application of local heat. The most serious complication occurred in the 12th case in the series. About four hours after operation the patient complained of sudden severe abdominal pain, and collapsed; immediate re-exploration of the wound revealed a large retroperitoneal haematoma due to slipping of a ligature; the spermatic artery, which had retracted considerably into the depths of the psoas space, was located and secured with some difficulty. The patient, however, made a good recovery in spite of this setback.

Wound infection was unusual. Mild infection characterized by erythema, slight swelling, and pain occurred in five cases; they all responded rapidly to the application of local heat. There were no examples of severe or persistent infection with pus or sinus formation.

No complaints were made of severe or persistent pain after operation, and the post-operative progress was straightforward.

Slight enlargement of the testis, associated with tenderness on palpation rather than pain, is usual for

about a week after operation. Within a fortnight the testis returns to a normal size and there is no tenderness. In 10 out of 84 cases attending follow-up examination the testis was found to be smaller than normal after three months, owing to atrophy.

Recurrences.—Eighty-four patients attended at least one follow-up examination at the third month, and 61 were seen after one year. There were five recurrences, four following the repair of direct hernias. The recurrences themselves were always of the direct variety.

Discussion

Celsus (*circa* A.D. 25) discussed the nature and origin of hernia and the early attempts at operative repair; from Roman times surgeons have been concerned with the need to preserve masculinity. In fact, the numerous operations devised for inguinal hernia show that little ingenuity has been spared to keep the inguinal canal open and preserve the integrity of the cord.

While it is true that in the case of oblique inguinal hernias of recent origin in infants, children, and young adults any interference with the normal mechanisms of the inguinal canal is unnecessary and even undesirable, the same cannot be said of larger hernias in older patients, where stretching of the internal ring has rendered these mechanisms obsolete. The reluctance to close the inguinal canal is determined more by prejudice than by reason, and the argument for the obliteration of the canal needs to be reconsidered. Firstly, most of the patients in whom closure of the canal is indicated have attained or passed the prime of reproductive activity (see Table I). Secondly, there has not been any evidence to show that the absence of one of a pair of functioning testicular units interferes with fertility in any way; unilateral cryptorchids are no less fertile than men with normal testes (Williams, 1960). Thirdly, the argument that closure of the inguinal canal invariably necessitates removal of the testis—"an intolerable affront to a patient's virility or its memory" (Ogilvie, 1959)—is no longer tenable since it has been shown, both experimentally on dogs (Heifetz and Goldfarb, 1952) and clinically, that the cord may be divided without gangrene of the testis. Thus the criterion of the psychological necessity of retaining a pair of testes in the scrotum is also satisfied.

The observation that the hernial sac emerges through the cord at the wedge-shaped junction between the spermatic vessels and the vas deferens, rather than to one or other side of the cord (Torek, 1937), emphasizes the weakness inherent in retaining this anatomical defect. Ligation and removal of the segment of the cord in the inguinal canal and its closure not only provides a complete repair of the defect in the parietes but forestalls the recurrent development of a hernial sac in the manner described by Torek.

Theoretically, at least, closure of the inguinal canal without removal of the testis appears not merely a feasible but a very desirable procedure in the treatment of suitable cases of inguinal hernia. In practice, however, the high incidence of complications in a series of 200 inguinal hernias so treated—six post-operative deaths, four cases of gangrene of the testis necessitating orchidectomy, 33 cases of severe wound infection, and 20 recurrences in the 169 cases that attended follow-up examination—seemed to favour the abandonment of such a procedure (Burdick and Higinbotham, 1935). A recent reassessment by Bodhe (1959), however, was more

hopeful; in a small series of 27 cases there were no deaths, no cases requiring secondary orchidectomy, and only two cases of mild wound infection. He also demonstrated, by carrying out testicular biopsy, that the viability of the testis does not suffer in any way, and that, in spite of division of the vascular supply, the structural arrangement of the testis remains much the same as that of a normal testis of the same age. And, although there is a loss of external secretion, the internal secretion is probably maintained.

In the present series there has been one death (from a subarachnoid haemorrhage), one retroperitoneal haemorrhage, five cases of mild wound infection, and five cases of scrotal haematoma. There has not been a single instance of severe or persistent infection with pus or sinus formation, nor a single case of gangrene or necrosis of the testis. The post-operative course and early progress of these cases has been almost without incident; subsequent examination has not revealed any physical or psychological disability, particularly with regard to masculinity and sexual function. It is debatable whether recurrence is a true recurrence of a bulge due to attenuated muscles; re-exploration of one case tends to support the latter view. The recurrence rate for direct hernias treated in this way has been much higher than for other types of hernia.

It may at first appear difficult to explain the discrepancy between these widely differing groups of results. The answer would seem to be centred on the development of wound infection. Burdick and Higinbotham described the infection rate in their cases as being "lamentably high," especially in those cases in which ox fascia was used. Although the precise incidence of mild infection is not stated, primary wound-healing occurred in only 159 cases (79.5%). Testicular gangrene and necrosis, peritonitis, and even the high recurrence rate may well be laid at the door of infection. Bodhe, in taking this view, attributes the lack of complications to the use of antibiotics; but as antibiotics have not been used at all widely in the present series the explanation must be sought elsewhere. It lies not only in rigid asepsis but in careful haemostasis and in the selection of suture material. The utmost care is required in preventing bleeding into the scrotum from the cut end of the cord above the epididymis. Double ligation of this is essential.

With regard to suture material, absorbable chromicized catgut was used throughout, reliance being placed on the soundness of the repair rather than on the strength of the material used. Primary wound-healing occurred in every case, and the absence of a single case of persistent sinus or severe wound infection has more than justified this choice, taken especially in the context of a general infection rate of nearly 6%, and a risk of chronic sinus formation of 2%, using non-absorbable sutures (Marsden, 1958). In his review of 1,000 cases of inguinal hernia there is a feature of further interest; of the 31 cases in which closure of the canal had been practised (combined with orchidectomy) there was not one recurrent hernia.

It is possible that the normal testis is less dependent on the testicular artery than has generally been thought; it is possible that the development of a collateral supply from the internal pudendal system of vessels is the response of the body to the ravages of atheroma which strike the aorta hardest near the origin of the testicular arteries. It is possible also that the pressure of a large

long-standing hernia provides a stimulus to the development of a collateral blood supply. The ability of the testis to survive this interruption of its vascular supply, however, is at present quite inexplicable. Division of the testicular vessels is sometimes likened to torsion of the testis, but this is a fallacy. Whereas torsion blocks the gateway to the testis (its mediastinum), division leaves this untouched.

In conclusion, while no plea is made for universal applicability, it is clear that this procedure is eminently feasible, and appears to offer a relatively simple alternative to the many complicated and involved procedures used in the repair of "unfavourable" types of inguinal hernia. The method, however, is not as effective in the treatment of direct hernias as it is in the other varieties.

Summary

A clinical study of 100 cases of deliberate closure of the inguinal canal has shown that the method is safe and may be used without added risk to the patients. Interruption of the blood supply to the testis through the cord was not followed by serious post-operative complications such as gangrene and sloughing of the organ. The procedure is a relatively simple means of dealing with the more unfavourable types of inguinal hernia—large indirect hernias of long-standing, recurrent, sliding, and combined (pantaloon) hernias—met with in surgical practice. Follow-up examination, though incomplete, showed five recurrences at the end of one year. Four of these followed the repair of direct inguinal hernias. The results suggest that the method is unsuited for the repair of direct hernias and is better confined to the other varieties, in which a reduced liability to recurrence may be expected. In them the repair that can be effected is sound, and the incidence of wound infection and sinus formation associated with the more complicated methods of repair is lowered.

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