STAINLESS STEEL WIRE FOR CLOSING ABDOMINAL INCISIONS AND FOR REPAIR OF HERNIAE

BY

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Stainless steel wire was introduced for the closure of abdominal incisions by Babcock in 1934. It has been adopted with success in other clinics, notably the Cleveland Clinic, where Jones, Newell, and Brubaker reported favourably on its use in 1941.

"One of the first clinical impressions of alloy steel wire used alone without stay sutures in the closure of abdominal wounds was the frequency of satisfactory healing, regardless of such adverse factors as carcinomatosis, deep jaundice, and general cachexia."

They confirmed the findings of previous authors (Dambrin; Kaufmann, Johnson, and Lesser) that the wire is well tolerated by the tissues, that it can be used in the presence of infection, that it produces solid closure, and that eviscerations are rare. When the wound is infected a residual sinus seldom occurs. The incidence of infection in clean wounds is markedly reduced.

Problem of Abdominal Disruption

We consider that the elimination of post-operative disruption is one of the most compelling factors in choosing stainless steel wire rather than catgut, silk, or thread in the closure of abdominal incisions. It is well recognized that disruption is relatively common and that when it does occur it is a very serious matter. Jones *et al.* (1941) reported 44 disruptions in 4,154 consecutive laparotomies not closed with steel (1.05%) with 15 fatalities (34% mortality); Meleney and Howes (1934) reported on 50 cases of abdominal disruption which occurred at the Presbyterian Hospital, New York, an incidence of about 1% of all their abdominal operations, with 22 deaths, a mortality of 44%. Relatively few of the latter cases were suffering from malignant disease, though it is well known that this is one of the most important factors predisposing to disruption (White, 1934).

Abdominal disruption is due to one or more of the following causes: (1) failure of the biological processes of wound healing; (2) interference with healing, or the dissolution of recently healed tissues, by a local infection or by digestive enzymes; (3) a disruptive force such as vomiting, coughing, abdominal distension, hiccuping, and sneezing.

(1) The strength of a wound correctly closed with stainless steel wire is unaffected by time, and is sufficient to withstand more than normal strains. It should therefore be used when there is any evidence of dietary deficiency, or where there is any factor present such as malignant disease or jaundice.

(2) Wound infection accelerates the dissolution of catgut and also prevents normal healing from taking place. The same is true of wounds bathed with biliary, pancreatic, or other digestive ferments. If non-absorbable ligatures such as thread and silk are used infection penetrates into the interstices between the filaments of the material and cannot be thrown off by the body until the ligatures have themselves been discharged. Stainless steel wire is a single inert filament offering no concealment or retreat for micro-organisms. No matter how serious an infection may be present or occur, granulation tissue grows on the surface of the wire, closing in over it without any residual pocket. The wire is heat sterilized, and there is no risk of it introducing infection.

(3) The strength of stainless steel wire is such that no disruptive force can burst a wound closed in one of the manners suggested. This certainty of strength is a great comfort to surgeons, assistants, and nursing staff. Come what may, the risk of abdominal disruption can be ignored. Confidence in the abdominal closure is easily transmitted to the patient, who is thus more likely to co-operate willingly in getting out of bed within or about 24 hours after the abdominal operation.

Ten Years' Experience

Our own experience dates from 1938, when we started using the wire for closing all major abdominal laparotomy incisions, especially in the presence of potential infection and in cases of malignant disease. The method was so uniformly successful that we adopted it almost as a routine. Soon we began using it for large incisional herniae which would have been very difficult to repair by any other method. The complete success attendant on these bad cases encouraged us to extend the use of wire to all herniae requiring reinforcement of the defect. Finally, one of us recently had occasion to close with wire an abdominal incision in the other. This enables us categorically to state that the patient is not aware of the presence of the wire.

We have used stainless steel wire in more than 2,500 major abdominal incisions and in a large number of minor cases in old or frail patients. There has been no instance of abdominal disruption or post-operative herniation. In a large proportion of the major cases the abdomen was opened for malignant disease. The patients have on the whole been seriously debilitated, and have provided a stern test of the methods here described.

It is too early to judge of hernial recurrences, because most of these repairs (there have been 300 so far) have been done during the last four years. We hope later to be able to have a sufficient number of cases followed up for proper assessment of results. So far there has been no recurrence.

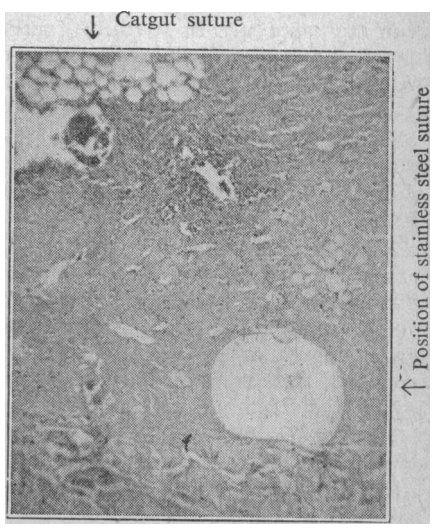

FIG. 1.—Photomicrograph of human abdominal wall 21 days after operation, to show absence of inflammation around stainless steel stitch and good deposition of fibrous tissue. Compare the catgut suture.

The Wire.—We use stainless-steel alloy wire, standard wire gauge 31 or 32 for abdominal incisions and large incisional herniae, 33 or 34 for inguinal and femoral herniae. It is strong, supple, smooth, and not ionizable in the body fluids. Knots can easily be tied with it and are secure. The tissues react to its presence by the formation of fibrous tissue only. We have demonstrated histologically in post-mortem material that there is no inflammatory or foreign-body response (Fig. 1). The wire, strong in itself, acts as a framework over which the body deposits a dense mat of fibrous tissue over a

narrow zone. The wire may or may not fragment after months or years, but the scar does not stretch.

Organisms cannot penetrate the smooth surface of the wire. It therefore does not act as an impediment to the healing of wounds which are infected at the time of operation, or which have become infected later. On occasions a sinus has formed (e.g., following operations such as the closure of a colostomy with a pericolostomy hernia), but this sinus has in our experience healed spontaneously. We have known of only one to persist for more than a week or two. This patient was a diabetic with a colostomy and three difficult herniae.

There are advantages to be gained from its use other than those due to its inherent qualities. Stay sutures, with their concomitant discomfort, liability to infection, and ladder scars, are never necessary. Our custom is to close skin incisions with Michel's clips, thus eliminating punctures through which infection may burrow from the surface. This is of particular advantage where there is risk of faecal contamination from an adjacent colostomy.

In dealing with hernial orifices we are of the opinion that stainless steel is the suture material of choice. No special instruments and no set of preconstructed filigrees are required. The method is immediately adaptable to the closure of an orifice of any size or shape. In fact the patient is given a "made-to-measure filigree." The security of the closure renders bed rest not only unnecessary but undesirable. The usual stay in hospital after herniorrhaphy is seven to ten days, after appendicectomy four to eight days, after gastrectomy 12 to 16 days, and the time away from work is correspondingly shorter than is the custom with the more orthodox methods of closure.

Method of Use of Stainless Steel Wire

Two principles must always be adhered to.

First, the anatomical relations of the parts sutured must not be distorted. Distortion implies tension, and tension leads to tissue necrosis. Stainless steel sutures must therefore be laid in the tissues without tension. The dissection prior to suturing or darning need involve only the immediate vicinity of the defect concerned. Fascial planes are thus not disturbed beyond a limited definition of the tissues.

Secondly, the wire must never be kinked. It will break at a kink. Care must therefore be used in all the processes of handling the wire, as well as in its introduction into the tissues.

The Needles.—Ordinary needles can be used, the wire being threaded through the eye and a short length twisted several times on itself. We prefer "atraumatic" needles which are affixed to the end of the wire: "eyeless" half-circle triangular No. 4 for laparotomy incisions and incisional defects, and Koenig's "fish-hook" No. 5 for inguinal and femoral herniae.

The Stitch.—The wire can be used for any type of suture, continuous or interrupted, superficial or deep; but the methods we describe below are those which we have found the most useful.

The first complete stitch is passed through the tissues and the wire tied in a close reef-knot so that the suture is taut but not tight. The short end is then gripped against the knot with a pair of artery forceps, cut level with the blade of the forceps, and the stump twisted 180° into the adjacent tissue. (It is best to keep an old pair of scissors, curved on the flat, specially for cutting wire.) In thin subjects with little subcutaneous tissue it is advisable to cut the loose end of the wire flush with the knot. The wire is then sewn in according to the methods described below, and finished off with a reef knot, the free ends being cut short and twisted in in exactly the same manner as at the beginning.

The assistant, throughout the whole process of sewing, holds the wire in a loose open loop, using both his hands. He allows the wire to follow without tension as the needle is passed through the tissues and catches it again as it is drawn out. By this means kinking is prevented. A convenient length of wire to use is 18 to 24 inches (45–60 cm.).

Closing Abdominal Incisions

Paramedian Incisions.—In our opinion the best method in patients of normal build is that of Babcock. The peritoneum, together with the posterior rectus sheath above the semilunar fold of Douglas, is closed with a continuous catgut stitch in the usual manner. The muscle and anterior sheath are then closed with a running "far-and-near" (i.e., figure-of-eight) stitch. (See Fig. 2.) Each "far" stitch is passed through the anterior rectus

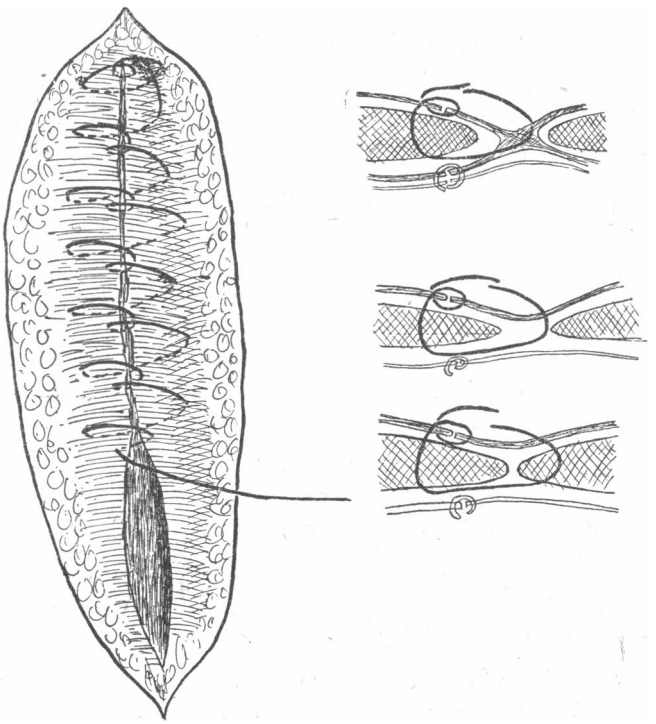

Fig. 2.—To illustrate the closure of paramedian incisions, the wire being retained.

sheath and muscle about 1 cm. from the line of section and brought out in the reverse order on the other side, again about 1 cm. from the cut edge. This stitch varies in its exact details, depending on the distance of the incision from the midline, whether it is above or below the semilunar fold of Douglas, and the degree of divarication of the rectus muscles. The "near" part of this "figure-of-eight" stitch takes in only the anterior rectus sheath. Each plane of the wound is thus accurately approximated, but it is most important that the stitches shall be pulled no tighter than just sufficient to draw the cut edges together.

In thin patients it is better to use interrupted "far-and-near" sutures and to cut each wire flush with the knot; or to use the following alternative method, which is convenient when it is required to reopen a paramedian incision. The wire is inserted in a manner somewhat similar to that used in sewing in a subcuticular suture, the anterior rectus sheath being approximated by a flat back-and-forth stitch which is not knotted. (Fig. 3.) The wire is introduced and brought out

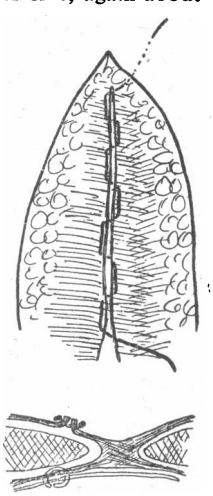

Fig. 3.—To illustrate the closure of paramedian incisions when the wire is to be removed.

through the skin at a little distance from the bottom and top of the incision and the ends are tied together in a loose loop over the inner layer of dressing. After twelve days one end is cut short and the wire pulled out.

Long Oblique or Transverse Incisions.—These are closed by using either a continuous "far-and-near" stitch (similar to that described above for paramedian incisions) or interrupted sutures.

Midline Incisions.—These are closed with a simple running stitch, the bites again being about 1 cm. deep.

The Repair of Hernial Defects

Inguinal Herniae.—Indirect sacs are dissected free, tied off, and removed in the usual manner. Direct sacs are similarly dealt with in cases where they merit such treatment. The transversalis fascia is sutured or plicated if this appears advisable. The posterior wall of the inguinal canal is then reinforced with a steel darn as in Figs. 4A and B. The needle is first passed

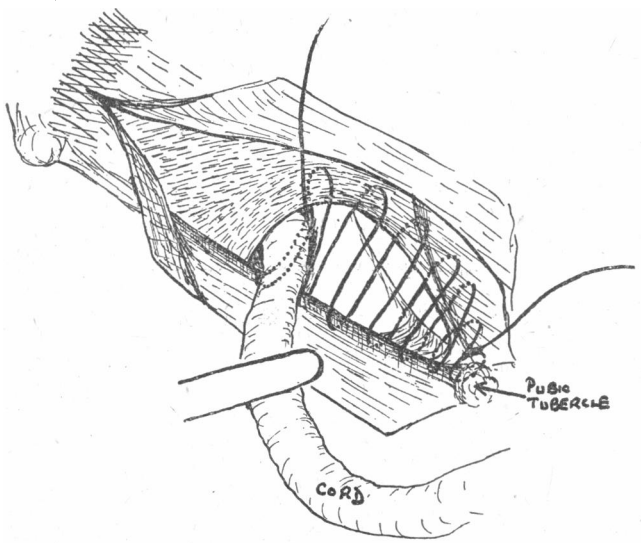

FIG. 4A.—To illustrate the darning with stainless steel wire of the posterior wall of the inguinal canal and reduction in size of the internal ring.

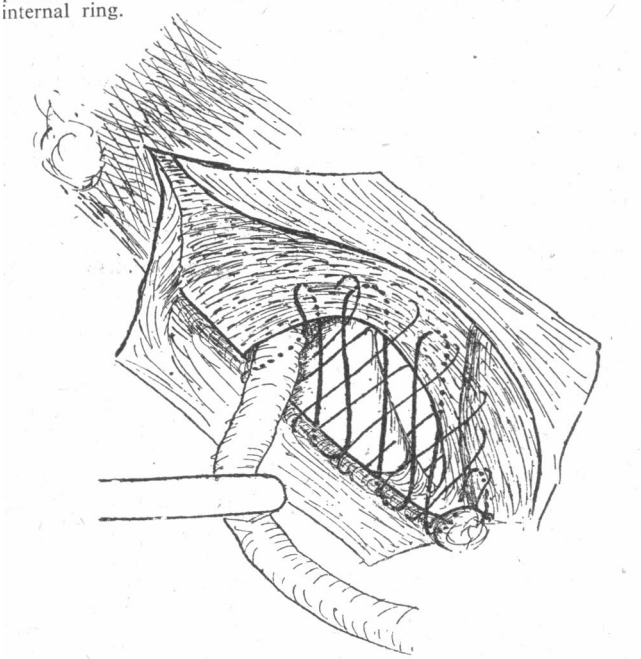

FIG. 4B.—To show the "return" darn.

through the periosteum covering the pubic tubercle, the stitch including the lower end of the anterior rectus sheath and the origin of rectus abdominis muscle. The wire is tied with a reef knot and the short end left about 4 in. (10 cm.) long. The next stitch takes a good bite of the rectus sheath and muscle above, Gimbernat's ligament and inner end of Poupart's ligament below; the next, the edge of rectus and conjoined tendon above, Astley Cooper's ligament and the inner end of the recurved edge of Poupart's below; the next, conjoined tendon above and the recurved edge of Poupart's below; and so on outwards to the internal ring, which is reduced to an appropriate size. Here, if necessary, the wire can be conveniently tied off and a fresh piece used for the return darn, which is brought back in a similar manner to the starting point of the suture. (See Fig. 4B.) This slightly more superficial "return" darn is placed obliquely to the first line of sutures so that a criss-cross or trellis-work pattern is formed. (Fig. 4B.) The upper bites are each at least 1 cm. deep: the weaker the tissues the bigger the bites.

The stitches are put in 5 to 7 mm. apart, considerably closer than in closing abdominal incisions. The wire is laid in the tissues without distorting the anatomical relationships as they are found, and each stitch is gently pressed into place. It is an advantage to have the edges of the divided external oblique aponeurosis held apart by a self-retaining wound-retractor. This tends to fix the gap between conjoined tendon above and Poupart's ligament below, enabling the steel darn to be inserted without drawing the edges of the defect together.

The placing of the stitches requires an exact and gentle touch on the part of the operator and his assistant, who holds the wire in an open loop with both hands as described above.

In some cases, particularly in direct herniae, the transversalis fascia is firmly attached to Poupart's ligament down to the pubic tubercle. Where this is so, it seems better not to break through this barrier in order to include Astley Cooper's ligament in the darn at the inner end, but to use Poupart's ligament throughout as the lower fixation of the wire.

The cord is then placed on the surface of the darn and the external oblique aponeurosis closed with interrupted thread or catgut or steel stitches. The skin is closed with clips.

Femoral Herniae.—These we approach from above. After the sac has been dealt with in the usual manner the femoral canal is occluded with a darn beginning at the pubic tubercle and carried outwards, passing between the outer edge of rectus abdominis and its sheath and the conjoined tendon above and Astley Cooper's, Gimbernat's, and Poupart's ligaments below. (Fig. 5.) The femoral vein is guarded in the usual manner and care is taken that it is not compressed by the outermost stitch. There appears to be no danger of erosion of the vein provided these precautions are taken. The darn is, of course, very much smaller than with inguinal herniae.

FIG. 5.—To show the placing of the wire darn over the femoral canal from above Poupart's ligament.

Recurrent Inguinal and Femoral Herniae.—The technique described above rarely needs to be varied for recurrent herniae, and our methods have so far met with complete success. Size is no contraindication.

Incisional Herniae.—After the sac has been dealt with the defect is occluded with a stainless steel darn which is carried from one edge of the opening to the other, good bites of at least 1 cm. in depth being taken of the tissues forming the ring. It is not necessary to carry out an extensive dissection to define the various layers forming the ring. No attempt is made to draw the edges of the ring together unless they fall into place without tension. For very large defects a length of wire 4 to 5 ft. (1.2 to 1.5 m.) long carrying a needle at both ends is more convenient, and the darn may be done on the "bootlace" pattern. (Fig. 6.)

Normally the darn becomes incorporated in tough fibrous scar so soon that the risk of strands becoming separated and a recurrence developing is remote.

Again, the size of the hernia or its ring is no contraindication to this operation. Any hernia can be dealt with. It is a relatively quick operation. The necessity for extensive dissections around the ring is eliminated. Therefore these repairs can often be carried out in poor-risk patients who would not be

able to stand plastic repairs, Gallie grafts, or operations such as Nuttall's.

Umbilical Herniae.—Where possible we close these by the Mayo technique, using interrupted stainless steel stitches. If there is any tension we use the method described above for incisional herniae.

Hernial repair with steel must be done with great care and precision, but compared with the various fascial graft and skin graft operations the method is simple.

Darning hernial defects with floss silk is easy and effective, but the threat of infection, accidentally introduced at the time of operation or arriving later at the site of the wound by way of the blood stream, caused us to give up this method soon after it had been introduced. There is no need to emphasize the unpleasantness of an infected floss-silk darn.

The stainless-steel wire method is somewhat similar to the silver-filigree operation of McGavin, as practised by Percival P. Cole. The filigree reinforcement, however, is laid over the defect and held in place with small stitches, whereas in the steel-wire method the reinforcement incorporates the margins of the defect in its meshes without strangulation of tissue. Should there be a recurrence following a filigree repair it occurs at the edge of the filigree. The method we describe obviates this source of trouble, in that the reinforcement is fused with the edge of the defect. There is a further advantage that a length of stainless steel wire can be used to darn a hernial defect of any shape or size, whereas filigrees need to be made up in sets and the sets maintained complete.

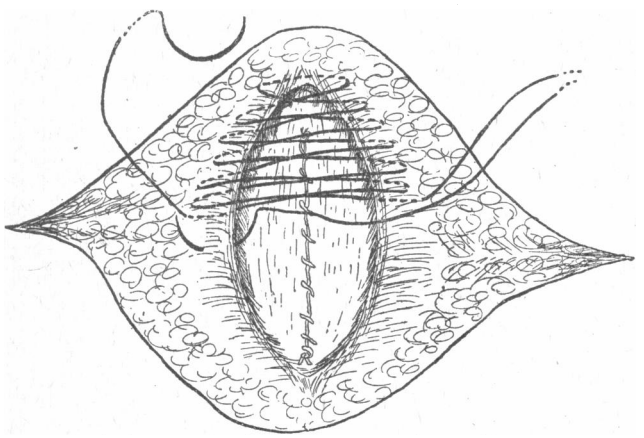

FIG. 6.—To show darning of incisional hernial defect after removal of the sac and closure of the peritoneum. (Needles mounted on each end of long length of wire.)

Some Observations

Wire handles differently from silk, thread, or catgut, but with a little experience it may be used with equal facility. Speed comes with practice, and we now find that closure of abdominal incisions by one or other of the methods described above is quicker than by any other practicable method.

In respect of tensile strength, holding power, absence of inflammatory and foreign-body reaction, rapidity of healing, and in the reduction of complications in an infected wound, stainless steel is better than catgut, linen or cotton thread, or silk. Wounds closed with nylon are more liable to become infected. This is probably due to the fact that it stimulates a fair degree of tissue reaction (Large). Also it is not so strong as stainless steel; it is less secure in the knot, and is more bulky. Tantalum wire induces the same type of favourable response on the part of the tissues and can be used as a monofilament suture. It is easier to use than stainless steel and has less tendency to kink. It is, however, not so strong and more brittle in the knot; it is difficult to procure and very much more expensive.

Dambrin records that exposure to *x* rays is without untoward result, and this has been our experience, though this aspect of the problem needs further investigation.

In about one case in every 200 a broken end of wire causes the patient discomfort and needs to be removed under local anaesthesia. This trouble has not been encountered except in the midline or paramedian closures in thin patients, and it is probably better to use interrupted sutures or the method illustrated in Fig. 3 in such subjects.

The reopening of an abdominal incision closed with wire takes a little longer than when catgut or thread has been used, but the method is easy. The skin and subcutaneous tissues are incised down to the wire loops. These are then defined sufficiently to be pulled up and divided between artery forceps, and the separate segments are then pulled out, care being taken to remove the whole wire. The knife blade used for this part of the incision is rendered useless for further work. There is no difficulty in closing a wound with wire for a second time.

In no case has the wire, or a fragment of it, burrowed into the tissues more deeply and caused trouble.

Summary

In our experience the use of stainless steel wire makes the closure of large abdominal incisions a clean procedure which is completely secure. It eliminates the risk of post-operative disruption and herniation. No such complication has occurred in over 2,500 consecutive major laparotomies, a large number of which were for malignant disease of the alimentary canal. Its use has been accompanied by a considerable reduction in the incidence of infection. Skin scars are neater. It has enabled us with great confidence to practise very early post-operative ambulatory treatment, with the concomitant benefits of a reduced incidence of distension and of pulmonary and vascular complications.

The use of stainless steel darns in the repair of hernial orifices has simplified the operation. Any hernia, however large the defect, can be repaired by this method. The closure seems to be more secure than by any other method in that we have had no recurrence in over 300 cases over a period of nearly five years.

We are of the opinion that the strong, smooth, fine, innocuous filament of stainless steel is at present the best material at our disposal for the closure and reinforcement of fibromuscular planes. It must be used correctly, without tension, without strangulation of the tissues, and without kinking of the wire.

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The Ministry of Health has issued a statement on the remuneration of chemists in the National Health Service. The scheme includes the following details, though interim arrangements will have to be made until they are fully worked out. Ingredients of medicines and appliances will be paid for at current wholesale prices as contained in the N.H.I. Drug Tariff with an additional on-cost allowance of 33⅓% (adjusted as necessary for purchase tax). Dispensing fees will be paid for most prescriptions at an average rate of 1s. each, and containers will be paid for at an average rate of 2½d. each. There will be additional payment for prescriptions marked "urgent" and dispensed when the shop is closed. For organized rota services chemists will receive 7s. an hour on week-days and 12s. 6d. an hour on Sundays and public holidays. Until this scheme comes into operation dispensing fees for prescriptions including those marked "urgent" and made up when the shop is closed will be paid at the current basic rates set out in the Drug Tariff with the addition of 161⅓%.