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The Shouldice repair for groin hernias

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Since the Shouldice repair was last described in this journal 10 years ago [1], many new techniques for hernia repair have been introduced. In spite of the enthusiasm with which each of these new procedures has been greeted, not all have lived up to their initial promise. With its continued high success rate, even after very long-term follow-up, it only makes sense to revisit the Shouldice procedure.

From its inception in 1945, 280,000 hernias have been repaired at Shouldice Hospital. The technique that has evolved is both therapeutic and prophylactic, as well as being patient centered, resulting in a truly holistic approach. The Shouldice repair is not only a successful pure tissue repair, but a total concept involving patient cooperation in preoperative preparation and early postoperative ambulation. The operative procedure itself, by necessity, embraces some features of other open groin repairs, but there are many aspects that are exceptional in both the dissection and repair. The entire groin region is dissected out and secondary hernias and weakness are searched for. The unique laminated closure allows the repair to be performed without tension, under local anesthesia. These elements, in combination, result in a repair designed to last a lifetime, as demonstrated by the follow-up of tens of thousands of patients over 50 years. Currently more than 150 abdominal wall hernias are repaired each week at Shouldice Hospital.

This article discusses the development of the Shouldice technique for groin repair and describes the operative procedure itself, highlighting those features that make it unique. A review of the extensive follow-up information, collected over 50 years, provides further insight into the success of this technique.

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History

E.E. Shouldice pioneered his approach to hernia repair and early ambulation, in the 1930s [2]. As a senior Army Medical Officer in the Toronto area during World War II, he noted an inordinate number of potential recruits being rejected from the Army due to the presence of a hernia. As part of his personal war effort, he operated, pro bono, on some 72 of these recruits. These 72 recruits formed a portion of the series of 272 patients on whom he reported at the Ontario Medical Association meeting in 1944 [3], although he did not write on his technique until 1953 [4]. In fact, this article describes his original procedure and does not include many of the features of the procedure as it is performed today. The patients undergoing hernia repair in those early days experienced the benefits of early ambulation the day of operation and no major complications ensued. His patients did not suffer the three-week-long postoperative hospitalization typical of the day, with all its inherent risks and complications. They returned home 3 to 4 days postoperation. Leithauser, in 1946 [5], credited Shouldice for pioneering early ambulation in Canada.

During this time local anesthetic use, suture material, and surgical technique all evolved. General or spinal anesthesia was used at first. Lack of available anesthetists, however, favored spinal anesthesia delivered by a GP anesthetist. In one case the spinal would not take; consequently, local anesthesia was attempted and proved successful. This positive outcome, coupled with the desire for immediate ambulation, induced Shouldice to adopt local infiltration anesthesia with ample preoperative sedation for the latter two-thirds of the series. The suture and ligature material of fine silk that was originally used caused problems with wound infection. In five cases sinuses developed and required surgical intervention. Four of these five cases were the second sides of bilateral hernia repairs. This prompted the scheduling of repairs of bilateral hernias 2 days apart, rather than on the same day. This delay also allowed any early complications resulting from repair of the first side to be picked up before the second was attempted. The concern arising from the use of silk caused a search for a more suitable ligature and suture material. Monofilament 32- to 34-gauge stainless-steel wire was tried, on the basis of being strong and relatively inert, and was subsequently adopted.

When WWII ended in 1945 hospital beds were in short supply and Shouldice, freed from military service, had a substantial list of civilians requiring his services, but no available facility in which to operate. After obtaining a private hospital license, he opened his own six-room surgical hospital specializing solely in repairing external abdominal wall hernias. This small hospital was located in downtown Toronto. It expanded gradually until finally an estate located just north of Toronto, in Thornhill, was purchased in 1954. The practice grew so quickly that both buildings were soon in full use. It was not until this author built a new 89-bed facility at the Thornhill site in 1969 that the downtown site, composed of merged 100-year-old houses, was closed.

It was in the initial 7 years, the "learning curve" years (Fig. 1), that problems were identified, analyzed and solved, and the surgical technique and management used today evolved. Contributing to these advances were the physicians who joined the staff, including Nicholas Obney (chief surgeon for 32 years), who performed more than 32,000 hernia repairs in his 40-year career, and Noble Black, who joined in a medical capacity and was responsible for the organization of the office, medical records, and the assiduous follow-up of patients. E.A. Ryan joined the group in 1950 and introduced the excision of the cremasterics to better view the canal floor. It was also at this time that splitting of the canal floor (posterior wall) was initiated, creating better exposure for finding secondary hernias and weaknesses. This enabled a further improvement, the transversalis fascia repair, starting at the pubic bone where direct hernia recurrences most commonly present. These maneuvers were incorporated into the technique by 1953 and the repair became standardized.

Ryan wrote, as well, on sliding hernias [6] and recurrent hernias [7]. These papers were based on the entire series to that date and attracted international attention. The staff continued to increase along with the workload, F. Glassow, A.F. Browne, and D. Welsh joining in the years 1953 to 1956. Glassow and Welsh, too, contributed a number of papers and presentations on the topic of the Shouldice hernia repair, as did R. Bendavid, who joined the staff in 1976. Bendavid and M.A. Alexander, who came on staff at the same time, introduced our use of prosthetic materials in

Fig. 1. Shouldice Hospital cumulative recurrence rate for hernia series 1945–2001.

the repair of large and difficult incisional and recurrent hernias. Alexander also devised the complete groin repair, a very successful pure tissue repair of femoral hernias.

Current status

Shouldice Hospital is a modern 89-bed inpatient facility with five operating rooms located on 23 acres in Thornhill, north of Toronto, Canada. The medical staff of 11 full-time surgeons performs more than 7500 hernia repairs annually. The clinic has historically drawn patients from around the globe, with 50.9% coming from outside of metropolitan Toronto and 20.6% from locations outside of Canada.

Ninety-four point three percent of the operative procedures since 1945 have been groin hernia repairs, made up of 55.3% indirect inguinal, 35.7% direct inguinal, and 3.3% femoral. Incisional, umbilical, epigastric, interstitial, Spigelian, and flank hernias comprise the remaining 5.7%. Of note is the frequency of secondary hernias found at the time of surgery (Table 1), a significant 15.4% of all inguinal hernias in the last 11 years. Were it not for the extensive dissection at the time of repair of the primary hernia, many would have been missed, resulting in recurrence. We feel that such secondary hernias and weaknesses, if missed, may well account for the widely held figure of at least 10% recurrence rate following inguinal hernia repair. This alone emphasizes the importance of a complete dissection, which will be discussed in more detail later.

Only 0.8% of our patient population is under 15 years of age, whereas 23% are over 65. This in turn influences the type of hernia seen, as sliding hernias, for example, are more frequent in the older age group. As well, only 6.3% of our patients are female; our incidence of female to male inguinal hernias is much lower than generally quoted.

Recurrent groin hernias (Table 2) form a significant part of our patient population: a full 10.4% of hernias repaired in the last 11 years. This unusually high percentage of recurrent hernias, out of keeping with what is generally seen in most surgical units, is likely due to the hospital's reputation of specialization in hernia repair resulting in more problem cases being attracted.

Table 1
Shouldice Hospital 11–year series (1991–2001) of groin hernias

Hernia type	Principal	Percent	Secondary	Percent
Indirect inguinal	43,432	60.13%	3439	7.92%
Direct inguinal	27,435	37.98%	6732	24.54%
Femoral	1361	1.88%	956	70.24%
Total	72,228	100.00%	11,127	15.41%

Secondary or "missed" hernias found in 15.41% of these operations.

Table 2
Percentage of recurrent groin hernias in shouldice Hospital 11–year series (1991–2001)

			Recurrent	
Hernia type	Total	Primary	Number	Percent
Indirect inguinal	43,432	40,437	2995	6.90%
Direct inguinal	27,435	23,404	4031	14.69%
Femoral	1361	859	502	36.88%
Total	72,228	64,700	7528	10.42%

Primary repair of inguinal hernias is performed in a pure tissue fashion according to the Shouldice technique. The tension-free nature of the repair speaks for itself, with very low recurrence rates over the long term. Local anesthesia aids in ensuring that the repair is truly without tension, as the muscle tone is more normal in patients under local than when they are totally relaxed under general anesthesia. Thus tension can be more appropriately judged and it is unlikely to occur in the repair. The use of prosthetic materials is reserved for those situations where recurrence following previous repair has left the groin area sufficiently damaged that inadequate native tissue remains to allow the surgeon to effect a strong, tension-free repair. Over the 11-year period from 1991 to 2001, 63,841 primary inguinal hernia repairs were performed using the Shouldice repair. Seven thousand and twenty-six recurrent hernias were repaired during this period; 6.4% of these recurrent inguinal hernias were repaired with the aid of prosthetic materials. Mesh was used in only 62 primary inguinal hernia repairs, fewer than 0.01%.

Surgical technique for groin hernia repair

Dissection

In hernia surgery as much attention should be given to the details of the dissection as to the repair. Without a delicate and thorough dissection a complete and lasting repair is difficult to achieve. As seen in our own series, such a dissection will reveal a significant number of secondary hernias. Our experience with repair of recurrent hernias is that regardless of the technique used at the initial repair be it open pure tissue, mesh or laparoscopic, dissection to obtain clear visualization of the anatomy appears to have been inadequate. It may be helpful to place the patient in Trendelenberg's position. This encourages the abdominal contents to drift away from the groin region, lessening abdominal pressure in the area and facilitating dissection and repair.

An oblique incision paralleling the groin crease gives the best exposure for all inguinal hernia repairs, as well as femoral hernias. Thus, a secondary inguinal weakness can be found and managed at the time of femoral repair. The incision should begin about 2 cm medial to the anterior superior iliac

spine and 2 cm or so inferior to it, running inferiorly, paralleling the groin crease to approximately 2 cm short of the pubic tubercle. If the incision is carried further in either direction, the superficial epigastric, ascending branches of the superficial circumflex iliac laterally, and the superficial external pudendals, medially, come into the operative field. Damaging the latter may lead to scrotal edema postoperatively.

The incision is deepened until the external oblique is seen. When the crura of the external ring are visible, one is assured of one's position and the operative field can be developed to the inguinal ligament and down to the pubic tubercle. In some cases, where a secondary hernia was present in the form of a femoral hernia, the lateral retractor tended to bounce out. This led to the incising of the thigh fascia just inferolateral to the inguinal ligament, a step that allows both discovery of a covert femoral defect and the freeing of tension. The freeing of the fat deep to the thigh fascia will expose the pectineal fascia, yielding good exposure to discover an occasional secondary femoral defect. By this maneuver, the inguinal ligament becomes well defined and retraction is facilitated.

At this point the external oblique is well visualized from the external ring distally to above the level of the internal ring medially. It can then be incised along the direction of its fibers, about 2.5 cm medial to its junction with the thigh fascia, extending the incision from about 2 cm above the internal ring down through the external ring. If the incision is placed too laterally (too low) there will be insufficient tissue along the lower flap of the external oblique, making repair difficult. An incision placed too medially will interfere with the exposure of the cord and floor of the inguinal canal. Care should be taken to confirm the plane through which the division of the external oblique takes place to avoid damage to the ilioinguinal nerve, which lies just deep to it. The nerve should be identified, preserved, along with the iliohypogastric nerve if seen, and both maintained clear of the subsequent dissection as atraumatically as possible. The deep aspect of the external oblique is then freed from the internal oblique and rectus muscle medially, and well-reflected laterally to expose the shelving edge of the inguinal ligament. This will allow proper inspection of the area lateral to the internal ring, enabling detection and repair of any muscular weakness or defect in the nature of an interstitial hernia. The spermatic cord, covered by fascia and the cremasteric muscle, can now be readily seen.

The cord coverings are initially divided longitudinally to allow mobilization of the cord and division of the cremasteric muscle. We feel that division and ligation of the muscle is essential for clear exposure of the floor of the inguinal canal. This prevents missed hernias, allows for control of tissue oozing, and permits proper reconstruction of the floor. Anastomosing vessels passing through the canal floor may be occasionally encountered near the pubis. If found, these must be divided to completely mobilize the cord and thus to give good exposure to the floor near the pubic tubercle, where a great number of recurrences are found. All cremasteric

structures—muscle, vessels, and genitofemoral nerve—are taken. Both stumps are doubly ligated, a step that reduces postoperative bleeding and hematoma. We have not noted any dependency of the testis following this procedure, nor do patients complain of this. To ensure no difficulties of this nature, the distal end of the divided cremasteric structure is secured during the closure to the newly formed external ring or subcutaneous tissue. The proximal end plays a role in the repair, being incorporated into the forming of the new internal ring.

Once the cord has been freed from its coverings, it must be separated from the internal ring, to allow clear visualization and detection of any indirect defect. If there is a readily visible indirect hernia sac, this may occasionally be easier to separate away from the cord first before dissecting the internal ring. Usually it is simpler to free the fascia at the internal ring first. Here the transversalis fascia formed the internal spermatic fascia when the gubernaculum testis passed through the anterior abdominal wall during fetal development. As well, at the internal ring, some of the fibers of the internal oblique extend down onto the cord forming the cremasteric muscle. The cuff of transversalis fascia (Fig. 2), which is continuous with the internal spermatic fascia, must be freed circumferentially to permit full mobilization of the cord. Once this has been completed, it is very rare in males not to find a small portion of peritoneum protruding down the anteromedial aspect of the cord. This structure must be identified and freed, as it may be the precursor of an indirect hernia. Indeed, if it protrudes below the level of the internal ring, failure to dissect it free may eventually result in an indirect recurrence. Gentle traction is exerted on the cord during the course of this dissection, so this lip of peritoneum does not have to be freed very far proximally. It should, and usually does, drop back into the abdomen and disappear.

At times, a gossamer-thin sac may be extremely difficult to detect. On other occasions, sacs may be hidden in fat or simply hard to find. These difficult-to-identify sacs can often be best located and freed by careful inspection of the cord just above the internal ring. If a sac is very adherent to, or extends well down the cord, we will divide it and leave the distal portion untouched. This prevents unnecessary trauma to the cord structures and may reduce the incidence of testicular atrophy. As noted by Glassow [8], we do not feel that high ligation of an indirect sac is necessary. We free and reduce completely an indirect sac or peritoneal protrusion. This is particularly true of sliding hernias, where preservation of the blood supply to the sliding viscus is critical. Often a good clue to the nature of a sliding element is the presence of fat accompanying the sac [9]. We readily reduce any sliding hernias and broad-necked sacs without attempting to open them. The only sac that we consistently open before reduction is a long narrow one, which might otherwise later cause incarceration.

Finally, the area superior and lateral to the internal ring must be visually and digitally checked to assure that there is no weakness or defect that might

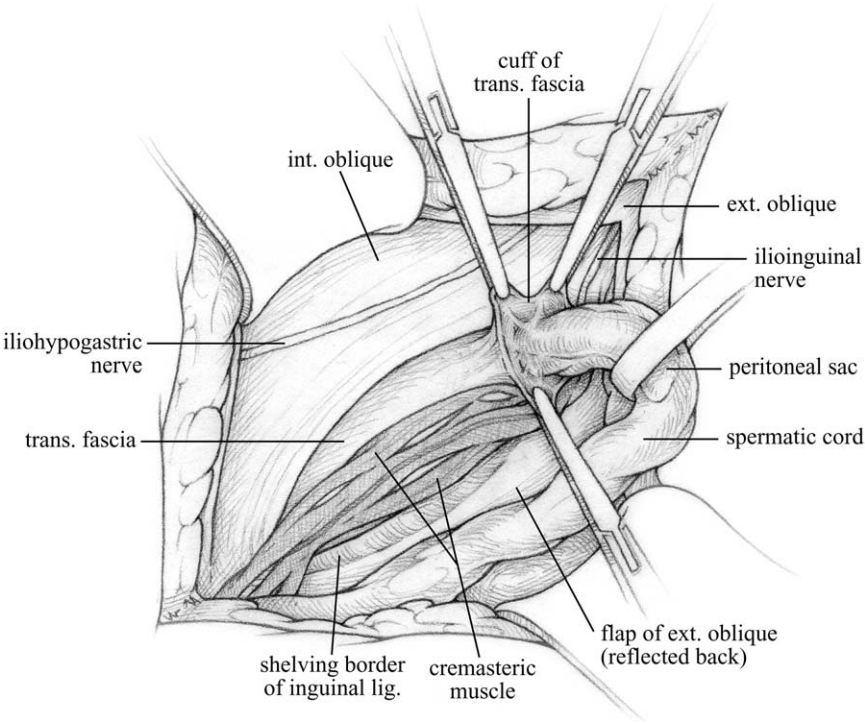

Fig. 2. Freeing the cuff of transversalis fascia from the spermatic cord at the internal ring. Note the cremasteric tissue lies intact on the canal floor but is being freed at the internal ring.

produce an early recurrence. Interstitial and Spigelian hernias, although rare, do contribute to the incidence of secondary (missed) hernias. The area of muscle beyond the internal ring may be considerably weakened, as found with large hernias. This weakness should be included in the hernia repair by simply extending the ring laterally with a split in the tissues to reach healthy strong muscle to form the new internal ring. This results in minor lateral displacement of the cord.

The final step in the dissection, that of the floor of the inguinal canal (occasionally referred to as the posterior wall), often omitted by inexperienced surgeons, is a critical factor in successful repair. Judging the strength of this structure by viewing it or by digital examination via the internal ring is not sufficient, as frequently intra-abdominal fat may be pushed forward by the examining finger and give a false sense of substance. We believe the only way to inspect the true strength of the canal floor (Fig. 3) is to split it at least half way, starting at the internal ring. This enables the freeing of preperitoneal fat from the deep surface of the transversalis fascia through to the pubic bone. Most floors require splitting at least two thirds to three quarters of their length, if not completely, to assure a secure repair.

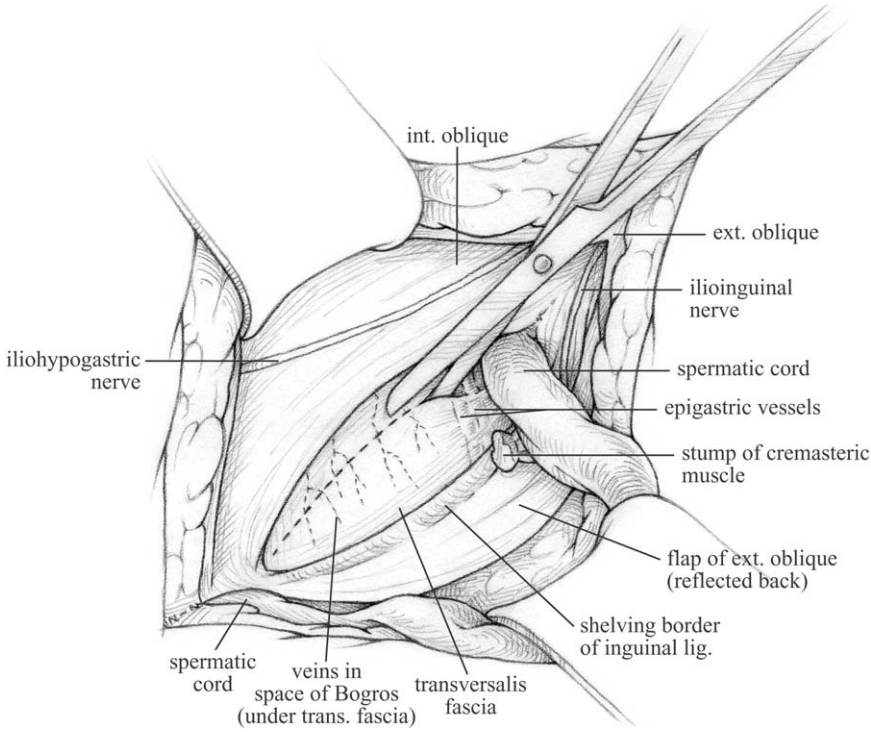

Fig. 3. Splitting of the transversalis fascia from the internal ring to the pubic crest as far as desired.

The canal floor in women is usually not as thinned and attenuated as in men and does not require splitting more than halfway. In the presence of a direct hernia the canal floor should be split until the surgeon is satisfied with the strength and quality of the remaining tissue. This splitting of the floor may be readily initiated following freeing of the transversalis fascia at the internal ring. The dissection is simply carried slightly medially at the muscular border and the fascia is freed over the inferior epigastric vessels, then divided. The splitting of the floor medially ends as the fascia thickens to meld with Cooper's ligament. It is at this location that the first suture in the repair is usually placed.

The division of the transversalis fascia, and subsequent entry into the preperitoneal space, is a cause of concern to some surgeons with regard to bleeding. Bendavid [10] published a study of the anatomy of the space of Bogros, which is the lateral extension of the space of Retzius. He clearly described a vascular circle including branches of the inferior epigastric vein as well as the iliopubic (marginal) vein, which crosses Cooper's ligament. These vessels are small, usually 1 cm to 3 mm diameter, and lie on or within the preperitoneal fat and transversalis fascia. Awareness of the presence of

these vessels aids in their avoidance and control, and results in lower risk for hematoma. The other concern in this region is the remote possibility of entering a viscus, but with careful division and dissection this does not occur.

Once the floor has been split, excess transversalis fascia may be trimmed; however, enough must remain to affect a repair without tension. The majority of direct sacs, even large ones, may be reduced without being opened. Only if there appears to be a narrow neck present should the sac be opened. Urinary bladder may be present medially in these sacs, or as a diverticulum lie free within the sac, thus the incision into the sac is made anterolaterally. Any redundancy of a sac may be removed but this is not necessary.

Freeing of the deep surface of transversalis fascia from the preperitoneal fat is essential. This reveals the well-defined posterior edge of internal oblique and transversus muscle medially. The edge of rectus is also exposed closer to the midline. Laterally the fat is freed from the undersurface of the transversalis fascia to expose the well-defined shelved or curved portion of inguinal ligament and the iliopubic tract as these structures blend into one another. As the fat is freed, Cooper's ligament is defined. It is at this juncture that the femoral region may be inspected from above by inserting a finger under the well-defined inferolateral flap of transversalis fascia, while at the same time the area is exposed for observation from below. This is also a good time to check the full mobility of the cord and to identify the iliohypogastric nerve. This nerve lies on top of the internal oblique and must be protected from entrapment in the suture line. There are times when it is very difficult to find, but if included in the suture, it may cause postoperative chronic discomfort or even an acute pain problem.

In this manner the groin is not only fully prepared for a precise repair, but all areas at risk for potential secondary or recurrent hernias, be they indirect, direct, femoral, or interstitial beyond the internal ring, have been carefully examined and ruled out or included in the repair.

Inguinal repair

Clinical assessment regarding the presence of secondary hernias has proven to be unreliable. Following the dissection described above, all repairs are performed to correct both indirect and direct defects, along with any weaknesses, regardless of the size or which type of hernia was identified preoperatively.

At this point a comment should be made regarding the suture material. Before the development of modern synthetic monofilament suture material, fine-gauge stainless steel was used for its properties of bacterial resistance as well as excellent strength for its minimal diameter and bulk. Its knotting properties are excellent, eliminating the need for multiple throws and long ends. Although those inexperienced with wire may, during the learning curve, suffer some frustration if the wire is mishandled and kinks, leading to breakage, this material has proven to be inexpensive and consistently

effective in our hands. We have, therefore, continued to use 34- or 32-gauge wire in all four layers of the actual repair.

The first line of the repair

The initial suture (Fig. 4) is placed inferolateral through the transversalis fascia close to the pubic crest, but avoiding periosteum. It then is carried superiorly and medially without tension beneath the edge of rectus. The result is a strong well-anchored beginning, covering the area where direct hernia recurrences most often occur. Leaving the short end for later use, the suture is then run taking the inferolateral flap of transversalis, again without tension, medially to the transversalis fascia lying on the deep surface of, first the rectus, and then the transversus and internal oblique muscles (Fig. 5). Unlike the first stitch, these bites are not full thickness medially and take only a small quantity of the tissue of the superomedial flap. The suturing between the two extreme ends of the repair are not through full thickness, but amount to no more than tacking the lateral mobile flap to the deep surface of solid significant structures medially. This goes a long way to avoiding tension. The suture line progresses superiorly toward the area of

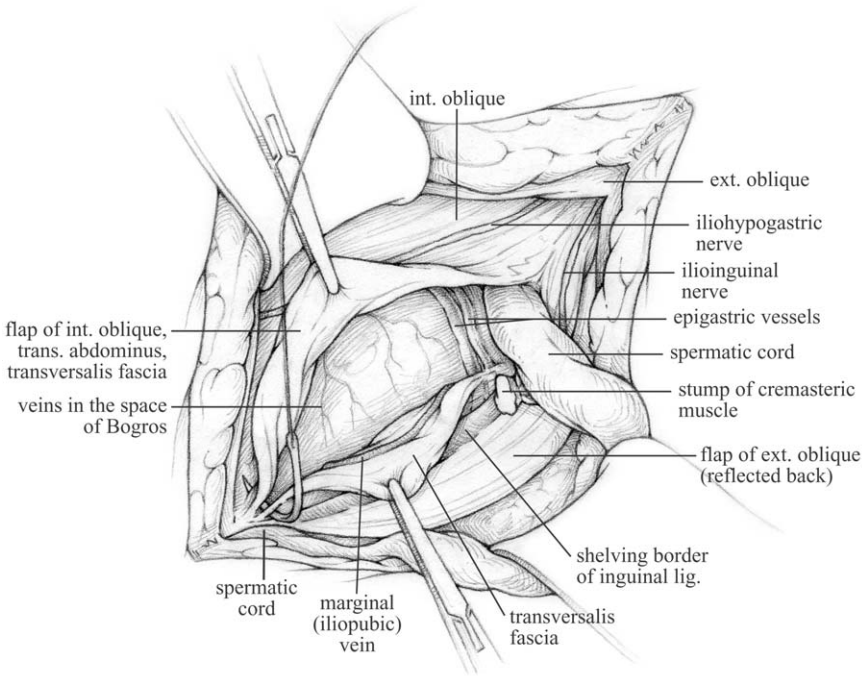

Fig. 4. Dissection completed. Note the marginal vein, other vessels in the space of Bogros, and the initial suture near the pubic bone.

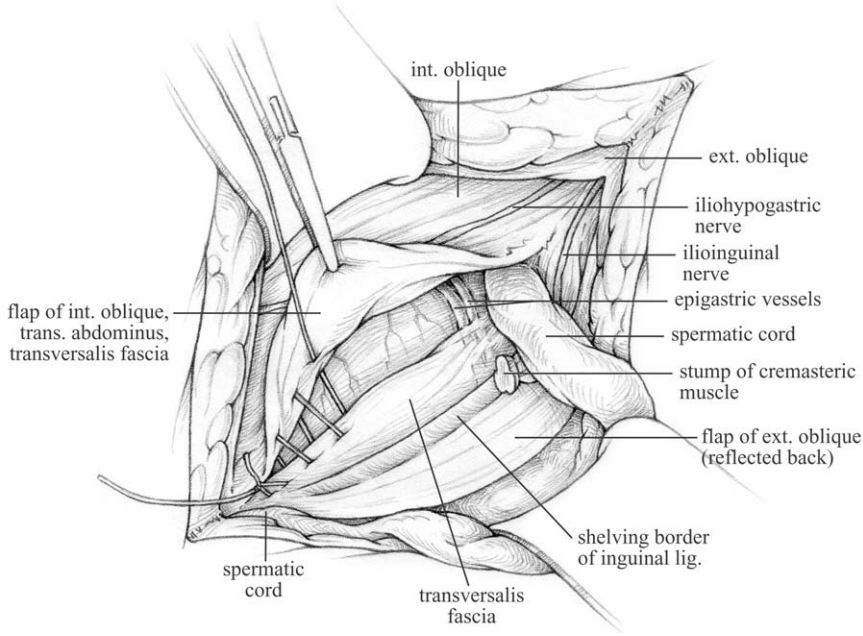

Fig. 5. First suture line continues to tack the lateral flap of transversalis fascia to the transversalis fascia lying medially beneath the rectus, transversus abdominis, and internal oblique muscles.

formation of the new internal ring. Here the quality of the transversalis fascia laterally may deteriorate somewhat. The internal ring (Fig. 6) is reformed by taking the lateral flap of transversalis fascia and the proximal stump of cremasteric muscle together medially across beneath the cord to the internal oblique, where a full thickness bite of tissue is taken. Thus the new internal ring is completely surrounded by muscle. This stitch may be snug but should not be tight.

This first layer of the repair is very strong in its medial centimeter or so and may well peter out superolaterally where, on rare occasion, essentially all that forms the initial layer of the internal ring is the proximal stump of cremasteric muscle. Although at times not strong in this lateral area, this layer is significant for a number of reasons. The primary reason for this layer is the strength it lends medially near the pubic bone, the prime area for direct recurrence. It also directs intra-abdominal pressure away from the abdominal wall and down to strong supporting structures—bone and ligaments. It serves to control preperitoneal fat during suturing of the remaining lines of repair. Finally, pocketing of the area anterior and medial to the femoral vessels, resulting in weakness, can be corrected during the suturing of the first line because the transversalis fascia blends with the femoral sheath.

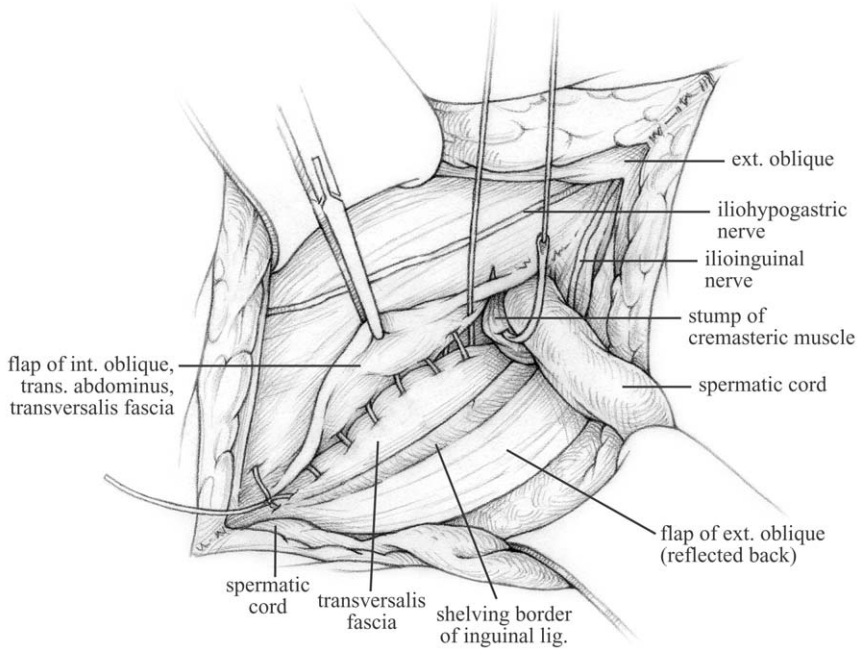

Fig. 6. Reconstruction of the internal ring incorporating transversalis fascia and the proximal stump of cremasteric muscle.

The second line of repair

Having initially reformed the internal ring with the final stitch of the first suture line, the suture is then reversed, initiating the second line of repair. Because the lateral flap of transversalis fascia has been carried under the medial tissue margin, a distinct flap of tissue has now been created medially. The second line (Fig. 7) carries this newly created flap down to the shelving or curving edge of the inguinal ligament that had been cleared earlier when the external oblique was reflected laterally. Full-thickness bites are taken of the edge of this flap, including the margin of the transversalis fascia along with any easily accessible transversus and internal oblique muscles. Care should be taken to use only small bites, thus avoiding tension on the suture line. Medial to the femoral vein, deeper bites of the inguinal ligament may be taken. The line is carried beyond the initial suture of the first line medially and returned again to be tied to the preserved free end.

The third and fourth lines of repair

These two suture lines complete the laminated repair. This time the initial suture is placed at the internal ring. A small amount of the external oblique (Fig. 8), close to the inguinal ligament, is carried to the superficial surface of the internal oblique. This line is continued, without tension, to the pubic crest and then reversed, carrying a final flap of the external oblique (Fig. 9)

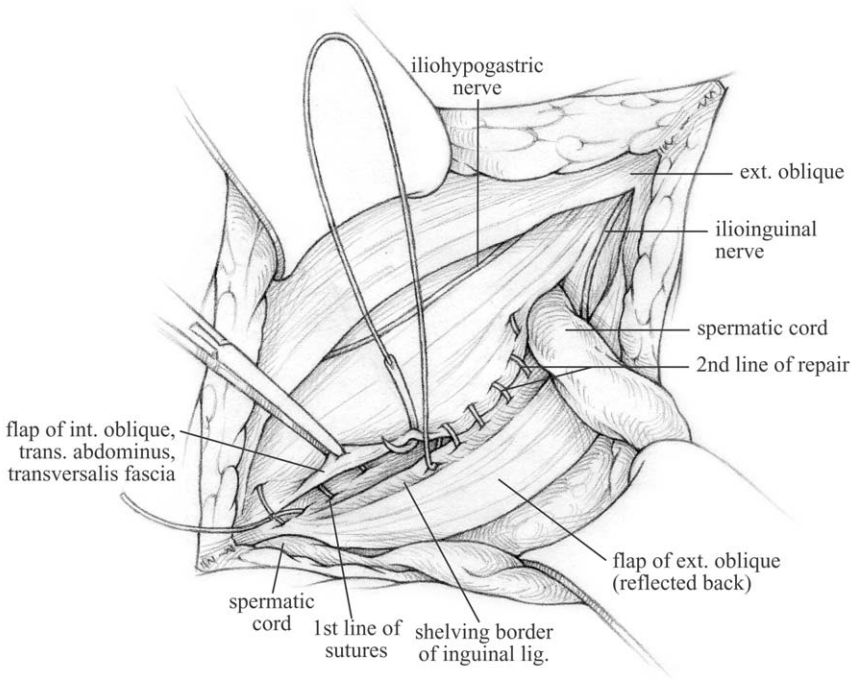

Fig. 7. Second suture line "carrying" the previous established medial flap of tissue to the curved or shelving edge of the inguinal ligament.

over the muscle layer above, until the new internal ring is once again reached. This provides a laminated closure of the floor as well as depth to the internal ring, which is not tight, but merely snug. A curved Kelly forceps may be inserted through the ring to confirm adequate laxity and to rule out any bleeding. Any excess cord can be reduced up through the ring.

Closure of superficial layers

The spermatic cord is replaced in its anatomical position beneath the external oblique, transposed slightly medially. The external oblique is than closed over it with a single suture line of absorbable material. As mentioned earlier, the distal cremasteric stump is included into the external ring or subcutaneous tissue to prevent any possibility of the testis becoming dependent. Absorbable sutures are also used in the subcutaneous tissue and skin is closed with Michel clips. We have found that when the clips are loosened the day following surgery, and some removed, with the remainder being removed on the second postoperative day, the cosmetic outcome is excellent.

Results

Follow-up of patients having had inguinal hernia repair at Shouldice Hospital ranges from 1 to 56 years. (see Fig. 1) Over the past 10 years, the

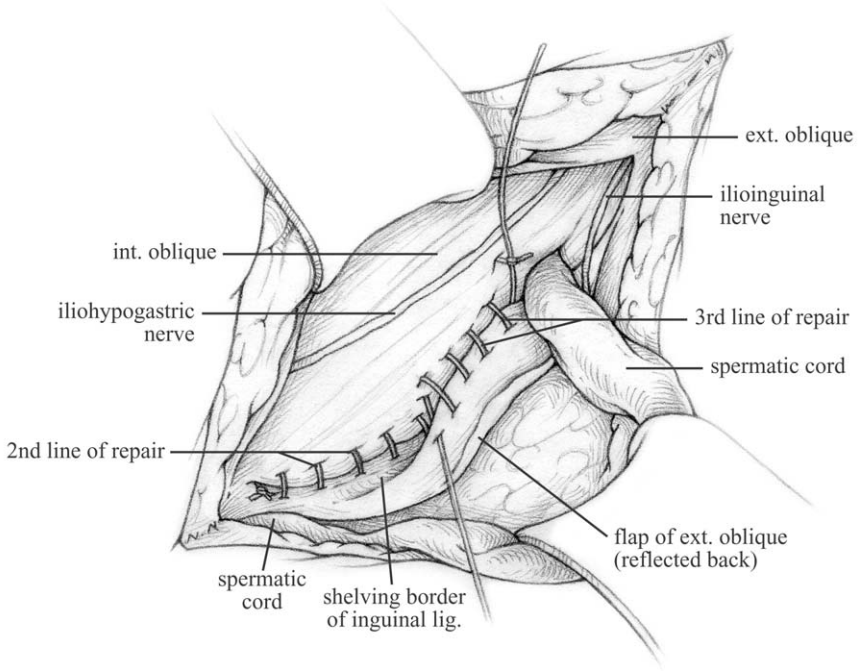

Fig. 8. The undersurface of the external oblique close to inguinal ligament is now in this third line of sutures being tacked over the internal oblique.

recurrence rate, obtained either by patient questionnaire or by direct examination by one of our surgeons, is 0.13% for indirect inguinal hernias and 0.31% for direct. An important fact that we have identified is the need for follow-up beyond the first 2 years. Among those patients operated on in 1985, there continues to be a gradual, though declining, annual recurrence rate over time (Table 3). The aim should be for a lifetime repair.

A feature of our follow-up is our traveling clinics. In 2002, a city was visited 250 miles from Toronto after 1649 notices for an impending recheck clinic were mailed. These notices covered a 75-km (45-mile) radius from the city and included all types of abdominal wall hernias. One hundred and sixty-two patients telephoned to book for appointments. There were 22 no-shows and 30 unannounced new patients. Thirty-eight percent of the patients examined had been operated on by us before 1990. Forty hernias were diagnosed, of which 4 were our recurrences. Eleven patients reported occasional mild degrees of discomfort and 2 hydroceles were noted.

Bilateral hernias

Most inguinal hernia repairs are elective operations; as performed under local anesthesia at Shouldice Hospital, we feel there is no urgency or need to

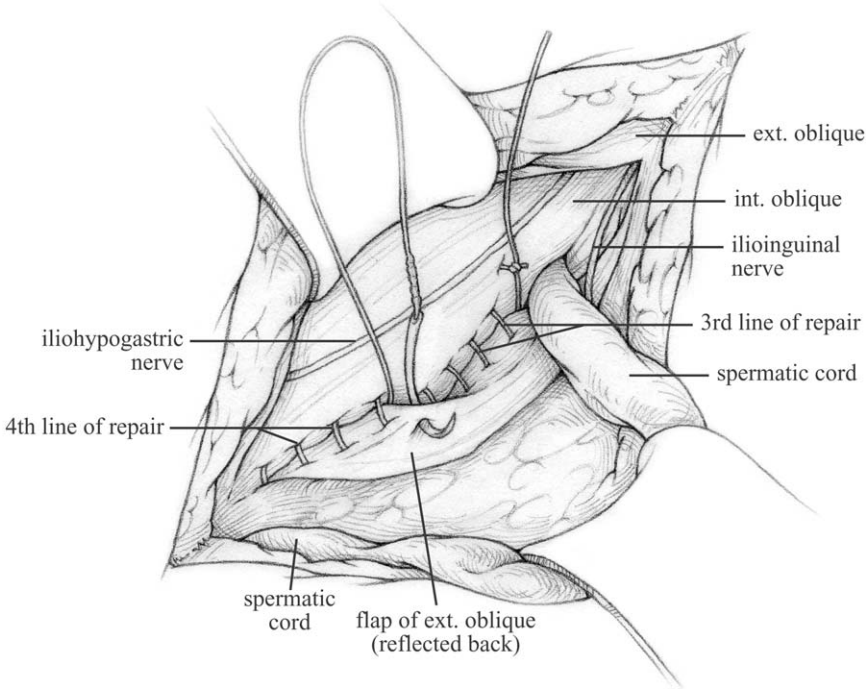

Fig. 9. The fourth line of sutures tacks more of the lower flap of the external oblique over the internal oblique.

repair bilateral hernias during the same procedure. Rather, bilateral hernias in adults are repaired on the same admission, but usually with a 1-day interval. Although somewhat conservative, this is in agreement with other centers [11]. There is less discomfort, the patient may elect to defer the second side if asymptomatic, the surgeon may decide more weight loss is required, and any early complications, medical or surgical, may suggest postponement. The delay is short, therefore not particularly inconvenient, and repeat anesthetic is not a concern because the operation is performed under local. Of those scheduled for a second side, approximately 88% proceed.

Femoral repair

Before 1984, results for the repair of primary, as well as recurrent, femoral hernias were poor, with a recurrence rate of 6.1% for the former and 22.2% for the latter [12]. This initiated our ongoing study for improving femoral hernia repairs, which we will be reporting. During that time, as well, there was an incidence of inguinal recurrence following femoral repairs from below where no exploration of the inguinal region had been performed at the time of the original femoral repair. Although initially mesh was used to try to decrease the recurrence rates, in 1984 Dr. Alexander, of our

Table 3
Results of 17–year follow-up of 6773 hernia repairs at Shouldice Hospital in 1985

Years	Recurrences discovered	Cumulative total
1985	2	
1986	5	
1987	4	11 in 2 years
1988	4	
1989	4	
1990	4	23 in 5 years
1991	3	
1992	3	
1993	3	
1994	1	
1995	0	33 in 10 years
1996	0	
1997	3	
1998	3	
1999	0	
2000	0	
2001	2	41 in 16 years

Recurrence rate after 17 years was 0.6%.

institution, introduced a pure tissue repair that is now one of the methods used for correction of femoral hernias when the inguinal ligament is intact. This repair, called the complete groin repair, also includes an inguinal exploration and repair of any other defect identified at that time.

Complete groin repair technique for femoral hernia

Dissection is performed in the same manner as for all groin hernias, including division of the transversalis fascia to allow a clear view of Cooper's ligament. Reduction of the herniated mass is facilitated by complete exposure and splitting of the posterior wall of the canal and dissection below the inguinal ligament, freeing the hernia. A sac is not always present in femoral hernias; fat alone is identified in 7.3% of our male patients and 4.4% of our female patients with primary femoral hernias. Once the femoral orifice is cleared of the hernial mass, permanent interrupted sutures (Fig. 10) are passed initially through the defect from below and through Cooper's ligament then carried anteriorly and superficially through the inguinal ligament and iliopubic tract in wide loops. These sutures are placed about one centimeter apart closing off the defect and covering the area from the pubic tubercle to the femoral vein. These are left untied but clamped together with hemostats, with the free ends extending inferiorly toward the thigh. The repair then proceeds as with an inguinal hernia repair. The second line of suture, however, interlocks with the previously placed interrupted sutures across the femoral defect. Upon completion of the third and fourth lines of the Shouldice repair, the interrupted sutures are drawn up and tied, thus pulling the Shouldice repair

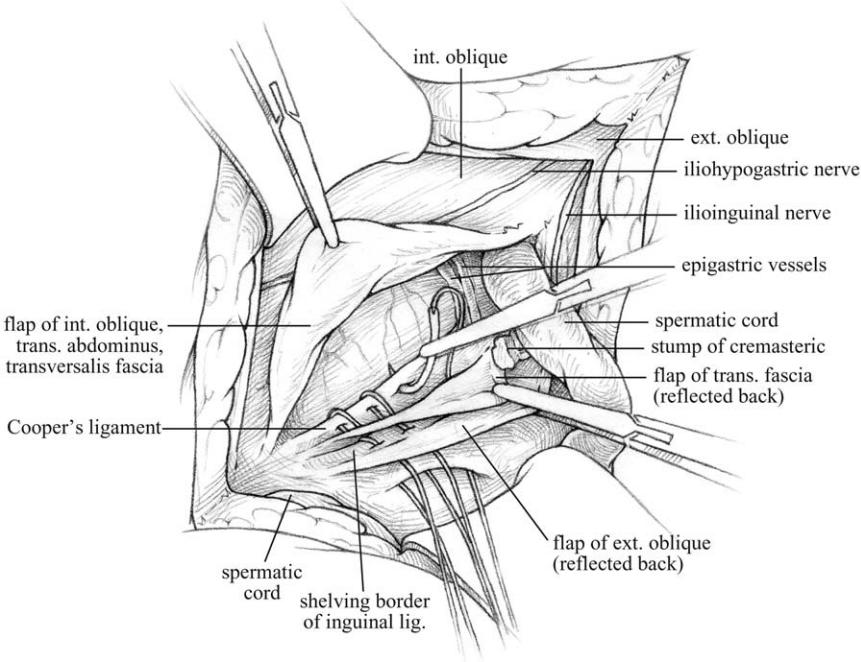

Fig. 10. Complete groin repair sutures being placed through the defect to pick up Cooper's ligament, then back out anterior and superficial to the iliopubic tract and inguinal ligament, in wide, loose loops.

toward Cooper's ligament. Sometimes, to avoid tension the tissues may not be completely opposed; however, in these situations the sutures appear to act in a similar manner to a mesh repair closure of the defect.

Results

Since 1986, 1361 femoral hernias have been repaired by a variety of methods, including mesh plugs and the complete groin repair. Nine hundred and fifty-six secondary femoral hernias or weaknesses were identified during the same time period at the time of inguinal hernia repair and these also were repaired by a variety of methods. Eight hundred and fifty-nine of the 1361 femoral hernias were primary hernias; their recurrence rate has been 2.4%, with a follow-up up of 1 to 15 years. Repair of the 502 recurrent femoral hernias has resulted in a recurrence rate of 3.0% over the same period.

Use of mesh for recurrent inguinal hernias

Conditions for use

We reserve the use of mesh for repair of hernias where the tissue has been either destroyed from previous attempts at hernia repair so that the remaining tissue is too weak and attenuated to provide strength, or

extensively scarred, inhibiting mobility. In 2001, there were 527 inguinal hernia recurrences repaired by our institution; 78 of these had had a previous mesh repair. We used mesh in repairing only 19 of the 527 recurrences (Table 4). We feel the failure of mesh repairs is in large part attributable to one of three causes. Recurrence could be due to a missed secondary hernia, inadequate fixation of the prosthetic patch, or even inappropriate placement of the prosthetic material. In this last group, typically the mesh was either an onlay (ie, superficial to the external oblique) or an inlay/overlay (between the external oblique and the canal floor). We concluded that, with the plug-in-a-bathtub analogy, the prosthetic material must be located on the pressure side of the defect, deep to the floor of the canal (underlay), to be effective. It must also be sufficiently large to extend well beyond the borders of the defect and to reinforce the entire canal floor and inguinal ring area. Finally, it must be well secured to prevent migration or rolling up upon itself. Thus for correct placement, full dissection to define tissue planes must be performed in the same manner as for a primary hernia. Our choice of prosthetic material is generally a polypropylene mesh (Trelex Natural mesh, Boston Scientific Medi-Tech, Wayne NJ) if peritoneum is intact; otherwise we use Gortex, (Bard Composix, Davol Inc., Cranston RI).

A further feature of our approach is that we will not attempt repair of a recurrent hernia within 6 months of a previous repair. We do this to allow tissues to fully heal and regain strength.

Results

Table 5 shows all the mesh repairs performed at Shouldice Hospital since our first case in 1983; 84 (2.2%) of the 3799 repairs have recurred to date. The table records the initial hernia types and subsequent recurrences.

In one of our previous studies, additional mesh prostheses were used in the course of repairing 67 (16%) of 416 previous mesh repairs. Forty-nine of these were multiple direct-inguinal recurrences—5 were five-time recurrent or more. To date, only 6 subsequent recurrences have been recorded from the entire case study. We have not been able to confirm one of these reported by correspondence. We have repaired 4 of the 5 confirmed recurrences; the fifth chose to be repaired elsewhere but has recurred again. As we all realize, some of these repairs can be extremely difficult.

Table 4
Percent of recurrent groin hernias requiring mesh repaired at Shouldice Hospital in 2001

		Mesh required	
Type of recurrent hernia	Total	Number	Percent
Indirect inguinal	233	2	0.86%
Direct inguinal	294	17	5.78%
Femoral	41	19	46.34%
Total	568	38	6.69%

Table 5
Shouldice Hospital mesh repairs from 1983–2002

Type of hernia	Number	Subsequent recurrences[a]
Inguinal	649	19
Femoral	647	11
Inguinal + femoral	478	6
Inguinofemoral	212	8
Prevascular	33	0
Incisional	1385	35
Umbilical	104	1
Epigastric	129	3
Umbilical/Epigastric	107	1
Interstitial	40	0
Spigelian	12	0
Lumbar	3	0
Total	3799	84

[a] Recurrence rate was 2.2%.

Complications

Hemorrhage is probably the most daunting of complications. Blood loss in or superficial to the repair resulting in a hematoma is unlikely to be a major problem. Bleeding deep to the transversalis, however, may result in sufficient blood loss to require transfusion. Our incidence of the latter is less than 1 in 5000. Careful dissection, double ligation of both cremasteric stumps, care, and awareness in the space of Bogros lead to a low incidence of hematoma.

Urinary retention presents three to four times annually in 7500 operations. Atelectasis, pneumonia and phlebitis are all exceptionally rare, thanks to early ambulation.

Infection has occurred in 0.6% of cases but has usually been mild and superficial; few cases broke down and discharged.

Our records indicate the rate of postoperative testicular atrophy to be 0.02% of primary repairs and 0.4% of recurrent hernia repairs. We believe the cause of this complication in one of our repairs is more likely trauma to the cord vessels than too tight an internal ring.

Anesthesia

The vast majority of cases, 96% or more, are performed under local anesthesia. As mentioned earlier, we find that a far more realistic assessment of tension in the repair can be made when the patient is not completely relaxed under general anesthesia. Also, local anesthesia enables the patient to strain on the table if a particular hernia is difficult to find. To repair larger, complicated, or multirecurrent hernias, a general anesthetic may be employed. For local we use 150 to 200 cc of 1% Procaine hydrochloride for local infiltration. Diazepam (10 to 20 mg orally) 90 minutes preoperatively,

and Meperidine (25 to 100 mg intramuscularly) 45 to 60 min preoperatively, are given for sedation. Immediate ambulation, arising from the operating table, is possible, and has both psychological and physiological benefits, particularly from a respiratory and circulation point of view. There is also less coughing in the immediate postoperative period when no inhalation agents are used, a distinct advantage. In elderly, pulmonary-compromised, and cardiac patients local anesthesia is very safe.

Patient care

Full patient cooperation, an important factor contributing to success, includes appropriate preoperative preparation. This includes weight loss by patients deemed to be overweight. In the nonobese patient the operation itself is easier for the surgeon to perform and the tissues are of better quality, more readily definable with more distinct planes. Fat obstructs the operative field and constantly contributes to the difficulty of dissection and repair. Obesity adds to intra-abdominal pressure and thus strain on any repair. Following weight loss, tissues are more lax, easing tension on the repair. Finally, the patients themselves generally feel better, with more energy, and have less discomfort in the postoperative period. Our goal is for patients to lose approximately 50% of their excess weight before surgery, but even five to ten pounds loss, equating to one to two inches in waist circumference, makes a difference. Fig. 11 shows the preoperative (indirect inguinal hernia) appearance of a 37-year-old fireman, operated on by our chief surgeon, Dr. Degani. He developed an enlarging hernia over a 3-year period. This patient, 5 feet 7 inches in height, originally weighed 296 lb. Over a period of 18 months, he reduced his weight 80 lb. The weight loss allowed complete reduction of the incarcerated mass, including bowel, without the need for pneumoinsufflation and with no respiratory compromise. A typical pure tissue repair was accomplished and recovery was routine and uneventful. The patient was discharged on the third postoperative day to return to work 4 weeks later.

Certainly one of the most innovative practices of its time was the early ambulation instituted by Dr. E. E. Shouldice in the postoperative care of his patients. At a time when patients remained recumbent in hospital for more than a week after hernia repair, Shouldice also pioneered early discharge. Although this approach is now followed by other surgical institutions, all too often there is insufficient support to ensure that full activities are maintained. In today's atmosphere of day surgery, the 3-day hospital stay of most patients at our institution may seem anachronistic, but we feel it is important to ensure that the early ambulation achieved is maintained. We admit patients on the day before surgery; this allows them to familiarize themselves with the surroundings and to prepare for what to expect postoperatively. The chance to mingle with postoperative patients bolsters their confidence. This is particularly important for elderly patients and those

Fig. 11. Massive right inguinal hernia in 37-year-old male who reduced 80 lb. preoperatively from an original weight of 296 lb.

who reside outside the metropolitan Toronto area. By the first postoperative day, patients are coached in gentle stretching exercises, take their meals in the hospital's dining room, and are generally fully ambulatory on the hospital grounds. Thus, at the time of their discharge patients are confident the repair is solid and activity will not produce complications. Any immediate issues have been closely observed and dealt with. Ninety percent of complications are evident the first postoperative day. We concur with findings that indicate that patient motivation is the biggest factor in the time taken for convalescence [13–15]. The average time off work for our patients is 8 days; 4 weeks is the maximum we authorize for return to heavy labor.

Conclusions

Repair of groin hernias remains a most commonly performed elective operative procedure for adult males in the western world [4,16,17].

Naturally this impacts significantly on the resources available for the delivery of health care. With all the various procedures available today it is reasonable, therefore, to ask where the Shouldice procedure fits into this landscape.

Traditionally, the main factor considered in the choice of hernia repair technique is recurrence rate. Preperitoneal mesh repair, mesh plug herniorrhaphy, and laparoscopic repair, whether transabdominal, preperitoneal, or total extraperitoneal, all have excellent results, in the range of less than 1% recurrence, when performed within a specialty center [18,19]. Outside such centers, recurrence rates tend to be higher, but remain comparable to each other [18,20]. One of the difficulties in fully assessing recurrence rates is the relatively short follow-up in many series involving newer procedures. It may be that the initially promising results do not hold up in the long term when compared with the extensive data collected on conventional tissue repairs, including the Shouldice technique.

The concern regarding recurrence rates is closely tied to the reproducibility of the technique and the ease with which it can be performed. Certainly the Shouldice method requires a clear understanding of the anatomy of the area being operated on, a laudable goal in any procedure. Furthermore, careful, precise technique, both in dissection and suturing, is necessary. It has been noted by many surgeons that there is a significantly steep learning curve for laparoscopic procedures, requiring about fifty to be performed before facility can be gained [11,14,17,20].

Rutkow has stated that "the measure of a herniorrhaphy goes beyond just simple recurrence rates"[14]. In the face of at least equivalent and possibly better repair results with the Shouldice technique, cost of the procedure itself must be examined in this time of fiscal responsibility. Laparoscopic and even tension-free mesh repairs incur a higher procedural cost from the materials alone than pure-tissue repairs. Local anesthesia provides a further saving in dollars compared with general anesthesia. The current case cost for a laparoscopic hernia repair, in a Canadian community hospital, excluding the cost of the mesh and anesthetic agents, is approximately $1300 Canadian (A. Loughlin, personal communication, 2002). A mesh plug alone is priced upwards of $200 Canadian. By comparison, current disposable costs for primary unilateral inguinal hernia repair at Shouldice Hospital are $19.82 ($12.87 US). The entire hospitalization cost for a patient at Shouldice, including surgery, nursing, and even food and linen, is significantly less than the operative case cost for laparoscopy. Many authors have questioned routine use of the more expensive modalities [14,16–18,21].

Proponents of laparoscopic hernia repair have countered that the increased procedural cost is offset by the earlier return to work. This is not a consistent finding. Literature suggests that motivation and the time required to return to work is actually multifactorial [13,15]; the method of hernia repair alone does not determine this outcome.

Another feature that must be taken into account when comparing operative procedures is the morbidity and mortality involved. All groin hernia repairs appear to run a risk of wound infection, hematoma, seroma, urinary retention, and chronic discomfort from nerve irritation or division. The use of mesh prostheses raises concerns regarding migration and those related to their foreign body nature, including chronic infection and fibrosis [22]. Stapling of mesh onto Cooper's ligament to close the defect is thought to be a potential cause of osteitis pubis [22]. Bowel and bladder injuries have been documented in laparoscopic procedures, as have incarcerated trocar site hernias [18,19]. These serious complications have not been noted in Shouldice repairs. Local anesthesia provides further protection against complications, with a lower incidence of pulmonary complications and urinary retention.

Prospective long-term randomized trials, which effectively compare all these factors, are difficult to perform. It would appear, however, that the Shouldice repair provides low recurrence rates, easily on a par with other procedures, low complication rates, and low cost. After more than 55 years and over 250,000 patients, the Shouldice procedure remains relevant in the armamentarium of twenty-first century hernia repair.

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