General Introduction and History of Hernia Surgery

1

Andrew N. Kingsnorth

Ancient and Renaissance Hernia Surgery

The high prevalence of hernia, for which the lifetime risk is 27% for men and 3% for women [1], has resulted in this condition inheriting one of the longest traditions of surgical management. The Egyptians (1500 BC), the Phoenicians (900 BC), and the Ancient Greeks (Hippocrates, 400 BC) diagnosed hernia. During this period a number of devices and operative techniques have been recorded. Attempted repair was usually accompanied by castration, and strangulation was usually a death sentence. The word "hernia" is derived from the Greek (hernios), meaning a bud or shoot. The Hippocratic school differentiated between hernia and hydrocele—the former was reducible and the latter transilluminable [2]. The Egyptian tomb of Ankhmahor at Saqqara dated to around 2500 BC includes an illustrated sculpture of an operator apparently performing a circumcision and possibly a reduction of an inguinal hernia (Fig. 1.1) [3]. Egyptian pharaohs had a retinue of physicians whose duty was to preserve the health of the ruler. These doctors had a detailed knowledge of the anatomy of the body and had developed some advanced surgical techniques for other conditions and also for the cure of hernia. The mummy of the pharaoh Merneptah (1215 BC) showed a complete absence of the scrotum, and the mummified body of Rameses 5th (1157 BC) suggested that he had had an inguinal hernia during life with an associated fecal fistula in the scrotum and signs of attempts at surgical relief.

Greek and Phoenician terracottas (Figs. 1.2 and 1.3) illustrate general awareness of hernias at this time (900–600 BC), but the condition appeared to be a social stigma, and other than bandaging, treatments are not recorded. The Greek physician Galen (129–201 AD) was a prolific writer, and one of his treatises was a detailed description of the musculature of the lower abdominal wall in which he also describes the deficiency of inguinal hernia. He described the peritoneal sac and the concept of reducible contents of the sac.

Celsus (AD 40) was a prolific writer and although he had no medical training, he documented in encyclopedic detail Roman surgical practice: Taxis was employed for strangulation, trusses and bandages could control reducible hernia, and operation was only advised for pain and for small hernias in the young. The sac could be dissected through a scrotal incision, the wound then being allowed to granulate. Scar tissue was perceived as the optimum replacement for the stretched abdominal wall. A common method of treating hernia at this time was to reduce the contents of the sac and then attempt to obliterate it by a process of inflammation and gangrene by applying pressure to the walls of the sac through clamping the hemiscrotum between two blocks of wood. The last of the Greco-Roman medical encyclopedists, Paul of Aegina (625–900 AD), distinguished complete scrotal from incomplete inguinal herniation or bubonocele. For scrotal hernia, he recommended ligation of the sac and the cord with sacrifice of the testicle. Paul was the last of the great surgeons who wrote several books, which gave detailed descriptions of operative procedures including inguinal hernia.

During the dark time of the Middle Ages, there was a decline of medicine in the civilized world and the use of the knife was largely abandoned, and few contributions were made to the art of surgery, which was now practiced by itinerants and quacks. With the rise of the universities such as the appearance of the school of Salerno in the thirteenth century, there was some revival of surgical practice [3]. At this time three important advances in herniology were made: Guy de Chauliac, in 1363, distinguished femoral from inguinal hernia. He developed taxis for incarceration, recommending the head down, Trendelenburg position [4]. Guy was French and studied in Toulouse and Montpelier and later learned anatomy in Bologna from Nicole Bertuccio. Guy wrote extensively about hernia in his book Chirurgia (Fig. 1.4), principally about diagnosis and methods of treatment. He described four surgical interventions: one of which

A.N. Kingsnorth (✉)
Department of Surgery, Peninsula College of Medicine & Dentistry, Plymouth, Devon, UK
e-mail: Andrew.kingsnorth@nhs.net

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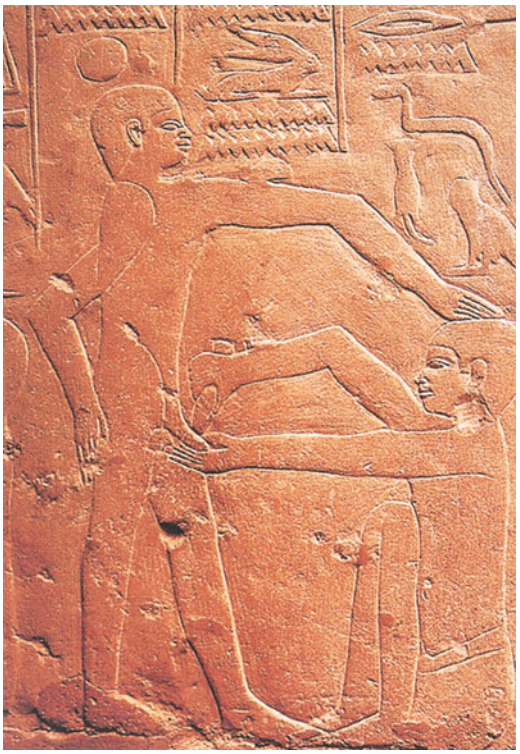

Fig. 1.1 Egyptian Tomb of Ankhmahor (Saqqara). The operator (*bottom right*) rubs in something with an instrument and seems to perform a reduction of an inguinal hernia

Fig. 1.2 Terracotta ex voto shows femoral hernia (from Geschichte der Medizin, 1922)

Fig. 1.3 Phoenician terracotta figure (female) shows umbilical hernia (fifth–fourth century BC) (from Museo Arquelogico, Barcelona, Spain)

was a herniotomy without castration, another consisting of cauterization of the hernia down to the os pubis, and third consisting of transfixion of the sac to a piece of wood by a strong ligature. His fourth method however was conservative treatment with bandaging and several weeks of bed rest accompanied by enemas, bloodletting, and special diet. At the time he was the authoritative expert on hernia.

Franco's book Traites des Hernies [5] standardized the practice of hernia surgery at the time and diminished the influence of the itineran practitioners (Fig. 1.5). Franco popularized the punctum aurium and using this instrument made a small incision in the upper scrotum, isolated the hernia sac from the spermatic cord, and then encircled it with a gold thread, thus sparing the testis. He chose gold thread because this was considered to be the best nonreactive material. In spite of the known hazards and high mortality of operating on a strangulated hernia, Franco advised early intervention and rejected the conservative measures employed such as bloodletting and tobacco enemas. As a result he saved numerous patients with lifesaving operations. He wrote many up as case reports illustrating his management and surgical techniques. He recommended reducing the contents and closing the defect with linen suture (Fig. 1.6). His beautifully written manuscript was rediscovered and published again in 1925 by Walter van

Fig. 1.4 The visit of surgical patients in Chirurgia. Guy de Chauliac, fifteenth-century manuscript (from the Bibliothèque Nationale, Paris, France)

Brunn. As shown in the illustration the unusual feature of the book was the patients posing in everyday attire as if they were going about their everyday life.

In 1559 Stromayr, a German surgeon from Lindau, published a remarkable contribution to surgery. His book Practica Copiosa describes sixteenth-century hernia surgery in great detail and is comprehensively illustrated. Stromayr differentiated direct and indirect inguinal hernia and advised excision of the sac and of the cord and testicle in indirect hernia [6]. Having differentiated and classified the two types of inguinal hernia, Stromayr recommended a testis-sparing procedure for the direct type. His operation for high ligation of an indirect sac at the internal ring is illustrated in Fig. 1.7. Stromayr also advanced the technology of trusses, which he designed to be adapted to the rigors of everyday life. The Renaissance brought burgeoning anatomic knowledge, now based on careful cadaver dissection. William Cheselden successfully operated on a strangulated right inguinal hernia on the Tuesday morning after Easter 1721. The intestines were easily reduced, and adherent omentum was ligated and divided. The patient survived and went back to work [7] (Fig. 1.8).

Without adequate interventional surgery, some patients survived hernia strangulation when spontaneous, preternatural fistula occasionally followed infarction and sloughing of a strangulated hernia. Cheselden's Margaret White survived for many years "voiding the excrements through the intestine at the navel" after simple local surgery for a strangulated umbilical hernia [7]. The closure of such a fistula in the absence of distal bowel pathology was described by Le Dran, who had noted that it was quite common for poor people with incarcerated hernias to mistake the tender painful groin lump for an abscess and incise it themselves. He found that these painful wounds with fecal fistulas required no more than cleaning and dressing. Often the wound would heal, nature preferring to send the feces along the natural route to the anus [8] (Fig. 1.9).

The Anatomical Era

The great contribution of the surgical anatomists was between the years 1750 and 1865 and was called the age of dissection [3]. The main contributors were Antonio Scarpa and Sir Astley Cooper, and few major advances in our knowledge of the anatomy of the groin have been made since this time. The names of these great anatomists are Pieter, Camper, Antonio Scarpa, Percival Pott, Sir Astley Cooper, John Hunter, Thomas Morton, Germaine Cloquet, Franz Hesselbach, Friedrich Henle, and Don Antonio Gimbernat.

The Dutchman Camper was a polymath who described a fascia, which is sandwiched in between the skin and deep fascia and can only be separated from this fascia below the inguinal ligament where the space between them accommodates lymph glands and cutaneous vessels of the groin. Below the external ring, Camper's fascia becomes the dartos muscle of the scrotum, which like the platysma is a muscle of the superficial fascia. Camper was the author of the definitive surgical text on hernia at the time. Antonio Scarpa was educated at the University of Padua (Fig. 1.10), and he occupied the chairs of anatomy at the University of Modena and later Pavia. He was said to be arrogant and tyrannical and as a result despised by his colleagues. Sir Percival Pott described the pathophysiology of strangulation in 1757 and recommended surgical management (Fig. 1.11): "I am perfectly satisfied that the cause of strangulated hernia is most frequently . . . a piece of intestine (in other respects sound and free of disease) being so bound by the said tendon, as to have its peristaltic motion and the circulation through it impeded or stopped" [9]. Pott was trained at St Bartholomew's Hospital and wrote the manuscript a Treatise on Rupture. This publication brought him into conflict with the Hunters who accused him of plagiarism for his description of congenital hernia, which they claimed to have described 2 years previously. He emphasized that the hernia sac was peritoneum

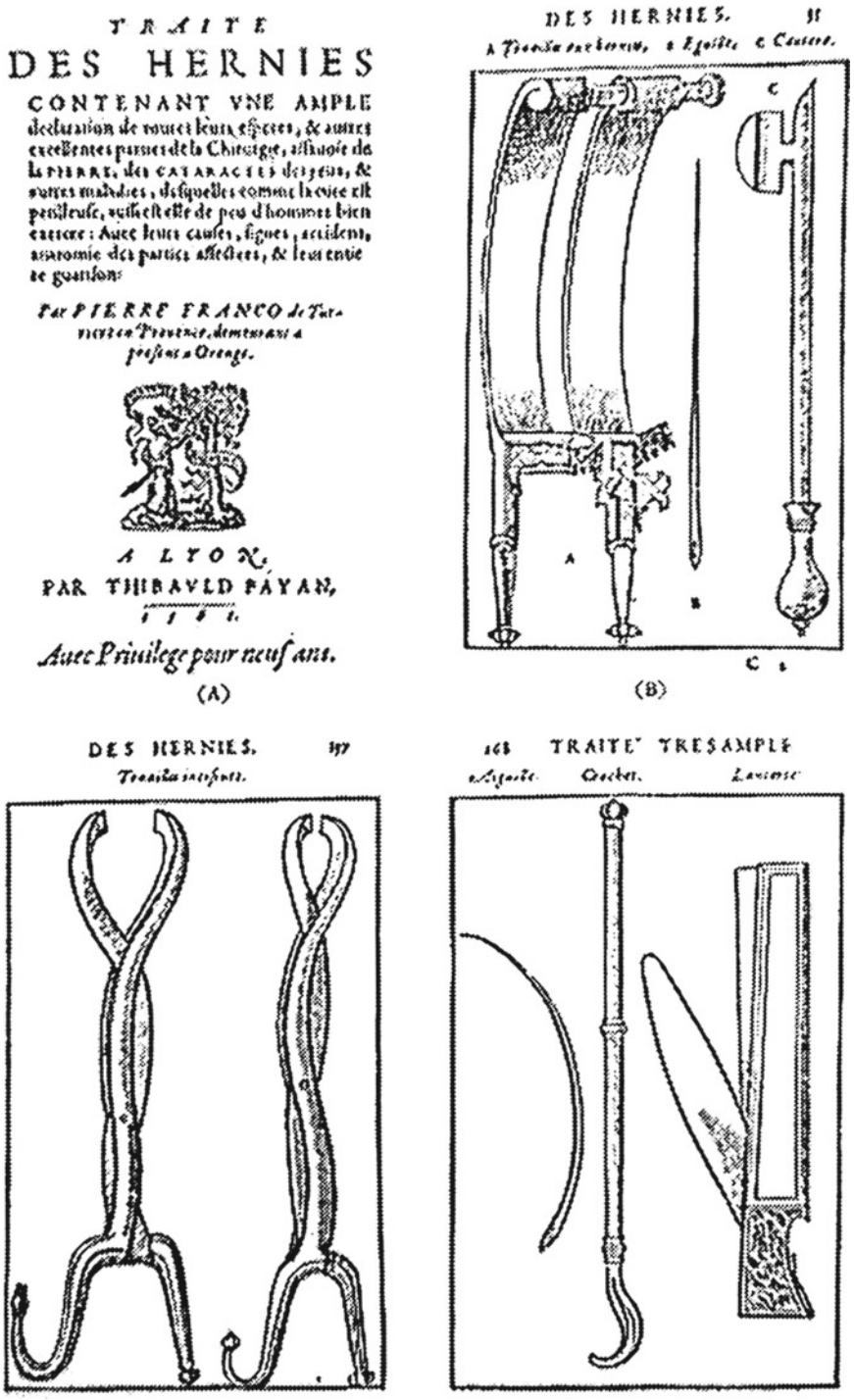
TRAITE
DES HERNIES
CONTENANT VNE AMPLE
PAR PIERRE FRANCO
A LYON,
PAR THIBAVLD PAYAN,
Auec Priuilege pour neuf ans.
(A)
DES HERNIES. 91
(B)
DES HERNIES. 197
168 TRAITE' TRESAMPLE

Fig. 1.5 Frontispiece and surgery instruments in Traités des Hernies (by Pierre Franco, Vincent, Lyon, 1561)

continuous with the general peritoneal cavity and had not been in any way ruptured or broken, which until that time was the popular theory of causation of hernia.

Fifty years later Astley Cooper (Fig. 1.12) implicated venous obstruction as the first cascade in the circulatory failure of strangulation: "By a stop being put to the return of blood through the veins which produces a great accumulation of this fluid and a change of its colour from the arterial to the venous hue." Nevertheless ligature, the insertion of setons, and castration remained the mainstays of treatment prior to the publication of Astley Cooper's monograph in 1804 [10] (Fig. 1.13). Sir Astley Cooper (1768–1841) trained at St Thomas's Hospital, London and became a surgeon at Guy's Hospital and from 1813 to 1815 was professor of comparative anatomy of the Royal College of Surgeons. Cooper published six magnificent books, two of

Fig. 1.6 Woman with femoral hernia. In Die Handschrift des Schmitt- und Augenartztes. Caspar Stromayr (by Walter von Brunn, 1925)

Fig. 1.7 The dissection of the sac and cord in an indirect hernia, carried to the level of the internal ring (in von Brunn, 1925)

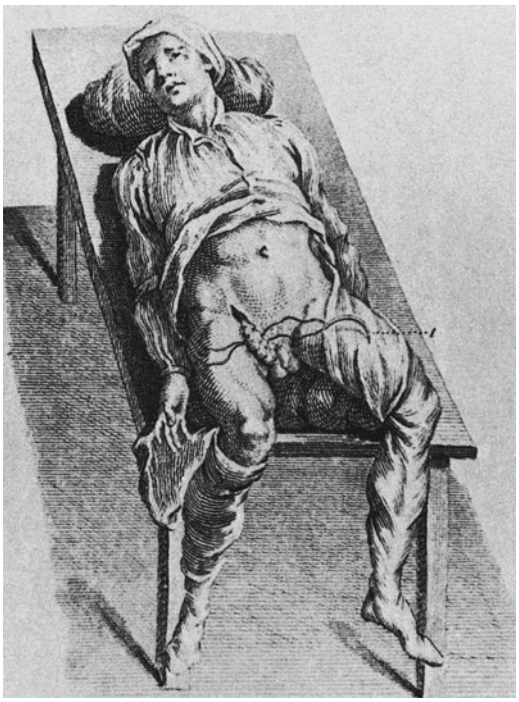

Fig. 1.8 Ligation of strangulated omentum in a strangulated right scrotal hernia. The wound then granulated. The patient survived and the hernia did not recur (operation by Cheselden in 1721 [7])

Fig. 1.9 Development of a preternatural colon fistula (colostomy) after strangulation of an umbilical hernia. The wound was trimmed. The patient survived many years "voiding" the excrements at the umbilicus (operation by Cheselden about 1721 [7])

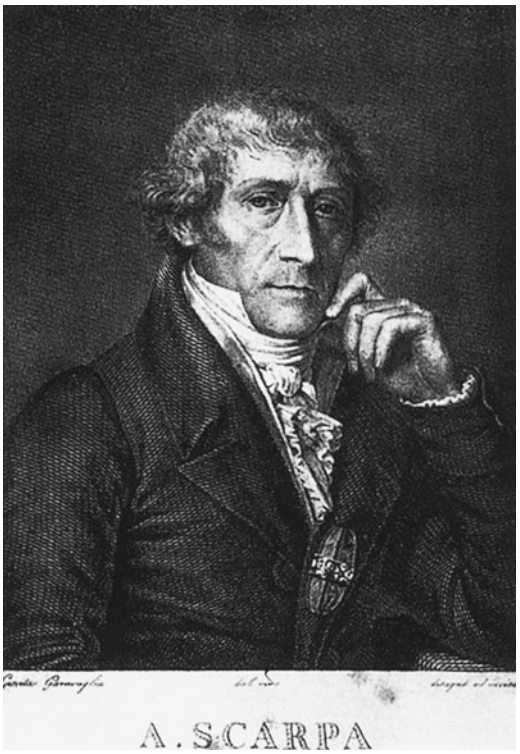

Fig. 1.10 Antonio Scarpa (1752–1832) professor of surgery and anatomy in Pavia, Italy

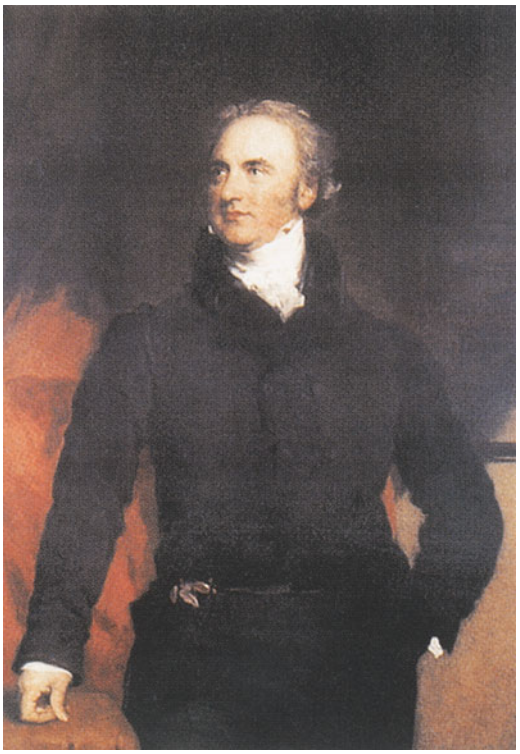

Fig. 1.12 Sir Astley Paston Cooper (1768–1841). Surgical anatomist, London, England

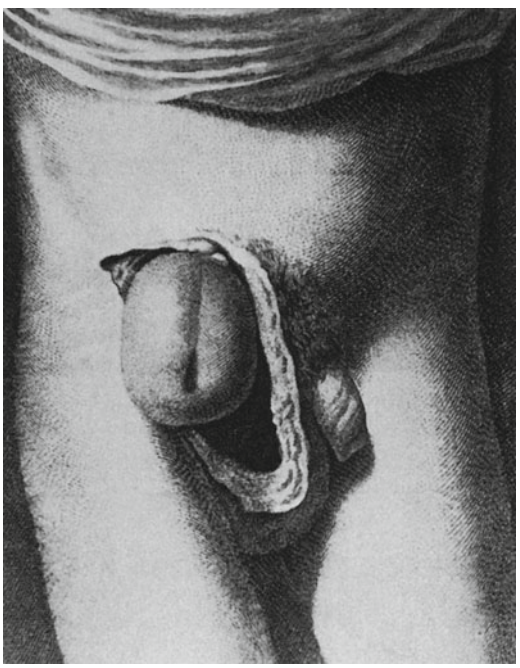

Fig. 1.11 Intestine strangulated by the "tendon" so that the venous circulation through it is stopped, leading to gangrene (described by Pott in 1757 [9])

which covered the subject of hernia, which were liberally illustrated by his own hand from dissections he had performed personally. Cooper was a charismatic lecturer and socialite and had an extensive surgical practice, which included being sergeant surgeon to King George IV. Cooper's recognition of the transversalis fascia positions him as one of the most important contributors to present-day surgery which emphasizes this layer as being the first layer to be breached in groin hernias.

John Hunter (1728–1793) was born in Glasgow but became a pupil at St Bartholomew's Hospital to Percival Pott and later served as a surgeon at St George's Hospital where he established his well-known anatomy lessons and later the Hunterian museum which is now housed in the Royal College of Surgeons of England. Hunter's contribution was to define the role of the gubernaculum testis that directed the descent of that organ with the spermatic vessels into the scrotum around the time of birth. Thomas Wharton (1813–1849), also a London surgeon working at the North London Hospital, in his short life, wrote three anatomical texts, two of which were the subject of inguinal hernia and the groin. He first gave an accurate description of the conjoined tendon of the internal oblique and transversus muscles and their termination and attachment to the outer portion of the rectus sheath.

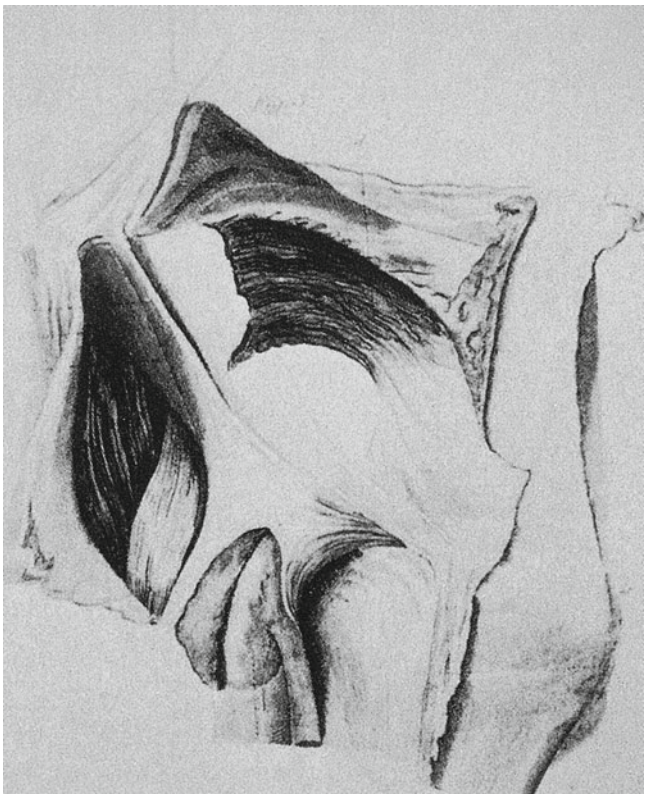

Fig. 1.13 Anatomy of the fascia transversalis. Astley Cooper (1804) demonstrated the fascia extending behind the inguinal ligament into the thigh to be the femoral sheath. He first recognized the fascia transversalis and its importance in groin herniation [10]

The first accurate description of the iliopubic tract, an important structure utilized in many sutured repairs for inguinal hernia, was made by Jules Cloquet (1790–1883). Cloquet was professor of anatomy and surgery in Paris and surgeon to the emperor. Cloquet researched the pathological anatomy of the groin in numerous autopsy dissections and their reconstruction in wax models. He was the first to observe the frequency of patency of the processus vaginalis after birth and its role in the production of a hernia sac later in life. Franz Hesselbach was an anatomist at the University of Wurzburg who described the triangle now so important in laparoscopic surgery which originally defined the pathway of direct and external and supravesical hernias (Fig. 1.14). The triangle as defined today is somewhat smaller. Friedrich Henle (1809–1885) was another German latterly working in the University of Gottingen. Henle described an important ligament running from the lateral edge of the rectus sheath and fusing with the pectineal ligament. This structure when present could be utilized to anchor sutures in herniorrhaphy. Finally Don Antonio Gimbernat (1742–1790) was a Spanish surgeon working in Barcelona and also surgeon to King Charles III and president of the College of Surgeons of Spain. Gimbernat not only defined the lacunar ligament as a distinct anatomical structure but also showed how its division in strangulated femoral hernia was usually the point of obstruction and allowed reduction of the contents of the sac.

The Era of Antisepsis and Asepsis

Before bacteria were recognized and with it the need for meticulous cleanliness in the environment of the operating theater, postoperative sepsis was virtually routine and mortality rates were extremely high. Oliver Wendell Holmes in 1842 and Semmelweiss in 1849 emphasized the importance of hand washing before operating. However, identifying and understanding the problem of infection and the causal bacteria had to await the discoveries of Louis Pasteur which were later put into practice by Joseph Lister (1827–1912). The application of Lister's principles of providing clean linen and special coats, special receptacles for antiseptic dressings, cleansing sponges soaked in carbolic acid and thymol, and the segregation of postmortem examinations and operating theaters profoundly influenced British and European surgeons and decimated postoperative infection rates. Modern Surgery Commenced with Lister's Discoveries [11].

Other important innovations were acquired before operative surgery presented a minimal danger to the patient. Ernst von Bergman invented the steam sterilizer in 1891 and introduced the word "aseptic." Halsted with the nurse Caroline Hampton introduced rubber gloves in 1896, and together with the introduction of a face mask by von Miculicz, the conversion from antiseptic to aseptic technique was finally set for the techniques of modern hernia surgery to develop [12].

The Dawn of Anesthesia

The removal of pain during surgical operations not only eliminated the terror of the surgical operation from the patient but also enabled more careful anatomical dissection and reconstruction and the evolution of planned surgical procedures [3]. An American dentist Horace Wells pioneered the use of nitrous oxide as an anesthetic, but his first public attempt at demonstrating a painless dental extraction was a failure. It was left to his associate William Thomas Green Morton to demonstrate the first successful anesthetic using sulfuric ether in the theater of the Massachusetts General Hospital in Boston. The operation on Edward Gilbert Abbott was for removal of a tumor angioma in the neck. Following this demonstration on 16 October 1846, the practice spread widely into Europe and Listen in London used it for a thigh amputation on Frederick Churchill on 21 December 1846. With patients no longer fearing pain, the scene was set for the great technological advances of the second half of the nineteenth century.

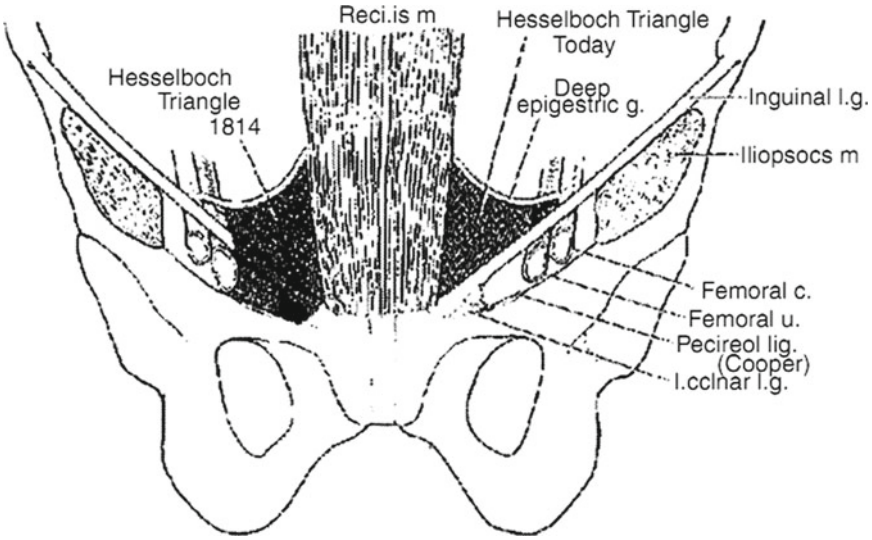

Fig. 1.14 The triangle of Hesselbach described in 1814, and as understood today. In Hernias (by JE Skandalakis, SW Gray, and JS Rowe Jr, 1983)

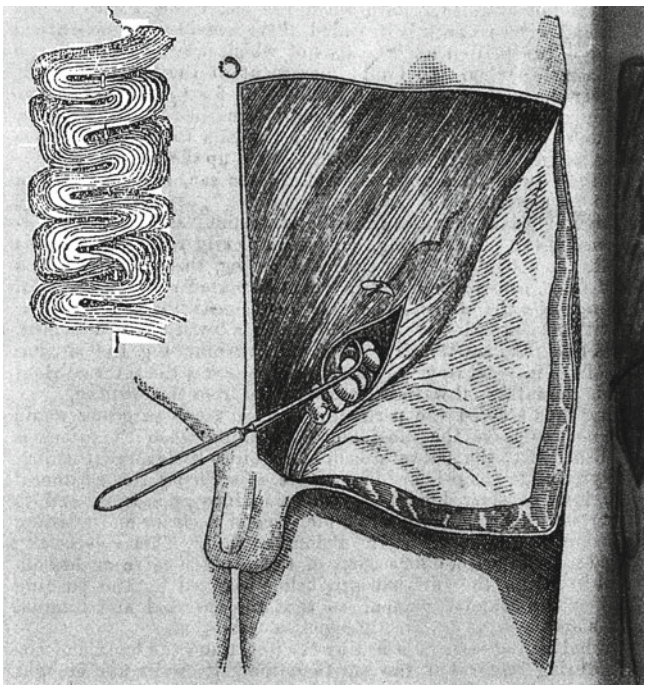

Fig. 1.15 The operation of McEwan 1886. The dissected indirect sac is bundled up and then used as an internal stopper or pad to prevent further herniation along the valved canal [15]

The Technological Era

Initial surgical attempts at hernioplasty were based on static concepts of anatomic repair using natural or modified natural materials for reconstruction. Wood (1863) described subcutaneous division and suture of the sac and fascial separation of the groin from the scrotum [13]. Czerny (1876), in Prague, pulled the sac of an inguinal hernia through the external ring, ligated it, amputated the redundant sac, and allowed the neck to spring back to the deep ring [14]. MacEwen (1886), of Glasgow, bundled the sac up on itself and stuffed it back along the canal so that it would act as a cork or tampon and stop up the internal ring [15] (Fig. 1.15). Kocher (1907), surgery's first Nobel Prize winner, invaginated the sac on itself and fixed it laterally through the external oblique [16] (Fig. 1.16). Suffice to say, none of these operations have stood the test of time.

As so often in surgery a new concept was needed before further progress could be made in herniology. Two (Figs. 1.17 and 1.18) pioneers—the American Marcy [17] and the Italian Bassini (1884)—vie for priority for the critical breakthrough [18–20]. Both appreciated the physiology of the inguinal canal and both correctly understood how each anatomic plane, transversalis fascia, transverse and oblique muscles, and the external oblique aponeurosis contributed to the canal's stability. Read, having carefully surveyed all the evidence, agrees with Halsted that Bassini got there first [21].

Although both contributed to herniology, Bassini made another seminal advance when he subjected his technique to the scrutiny of the prospective follow-up. Bassini's 1890 paper is truly a quantum leap in surgery [20]; indeed, if it is read alongside the contribution of Haidenthaller, from Billroth's clinic—reporting a 30% early recurrence rate—which appears in the same volume of Langenbeck's Archiv fur Klinische Chirurgie, Bassini's stature is further enhanced [22].

Marcy directed his attention to the deep ring in the fascia transversalis; his operation for indirect inguinal hernia entailed closure of the deep ring with fascia transversalis only, the object being the recreation of a stable and competent deep ring. In 1871, he reported two patients operated on during the previous year "in which I closed the (deep) ring

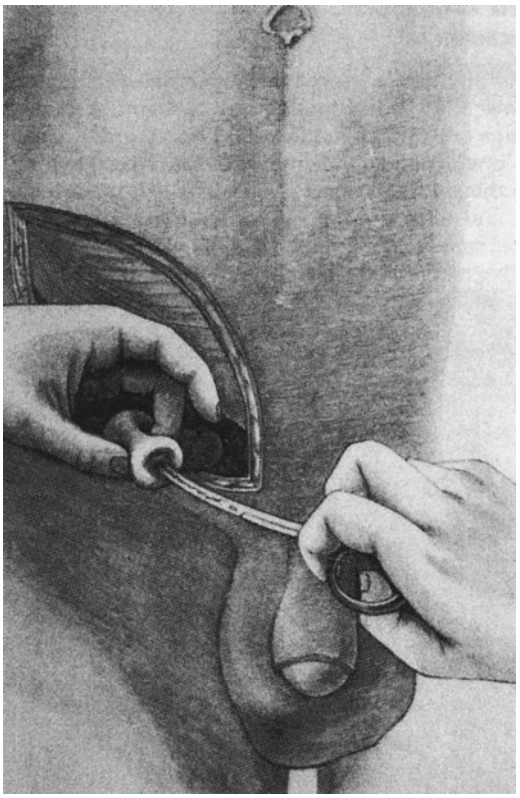

Fig. 1.16 Invagination of the sac which is fixed laterally by suturing its stump to the external oblique. No formal dissection or repair of the deep ring was made (operation by Kocher in 1907 [16])

Fig. 1.17 Henry Orville Marcy (1837–1924), Boston surgeon, anatomist, and philanthropist. The first American student of Lister (courtesy of the New York Academy of Medicine Library)

with the interrupted sutures of carbolized catgut followed by permanent cure" [23].

Bassini had become interested in the management of inguinal hernia in about 1883, and from 1883 to 1889 he operated on 274 hernias. After trying the operations of Czerny and Wood, he modified his approach and attempted a radical cure, so that the patient would not require a truss after surgery. He decided to open the inguinal canal and approach the posterior wall of the canal; gradually he was focusing onto the deep ring and fascia transversalis. Seven times he opened the canal, resected the sac, and closed the peritoneum at the internal ring. He then constructed a tampon of the excess sac at the internal ring and sutured this sac stump, or tampon, to the deep surface of the external oblique. One of his seven patients died 3 months after the operation from an unrelated cause. Postmortem examination showed the sutured portion of the neck, the "stopper" or tampon, to be completely reabsorbed. Bassini deduced that although the risk of recurrent herniation was diminished by this technique it did not afford adequate tissue repair, and some external support—a truss—would still be needed to prevent recurrence. He now proceeded to complete anatomical reconstruction of the inguinal canal.

> . . this might be achieved through reconstruction of the inguinal canal into the physiological condition, a canal with two openings one abdominal the other subcutaneous and with two walls, one anterior and one posterior through the middle of which the spermatic cord would pass. Through a study of the groin, and with the help of an anatomical knowledge of the inguinal canal and inguinal hernia, it was easy for me to find an operative method, which answered the above described requirements, and made possible a radical cure without subsequent wearing of a truss. Using the method exclusively I have, during the year 1884, operated on 262 hernias of which 251 were either reducible or irreducible and 11 strangulated.

His series included 206 men and 10 women; the nonstrangulated cases were 115 right, 66 left, and 35 bilateral inguinal hernias. The age range was 13 months to 69 years. The operations were performed under general narcosis, and there were no operative deaths; however, three patients who each had strangulated hernias died postoperatively—one of sepsis, one of shock, and one of a chest infection. Bassini's patients were carefully followed up, some to 4¾ years, and seven recurrences were recorded. There were, in fact, eight recurrences; Bassini failed to tabulate case 65, a 54-year-old university professor in Padua with a strangulated right direct inguinal hernia, with a recurrence at 8 months. The wound infection rate was 11 in 206 operations, and the time to healing averaged 14 days [20]. These statistics compare favorably with reports made up to the 1950s.

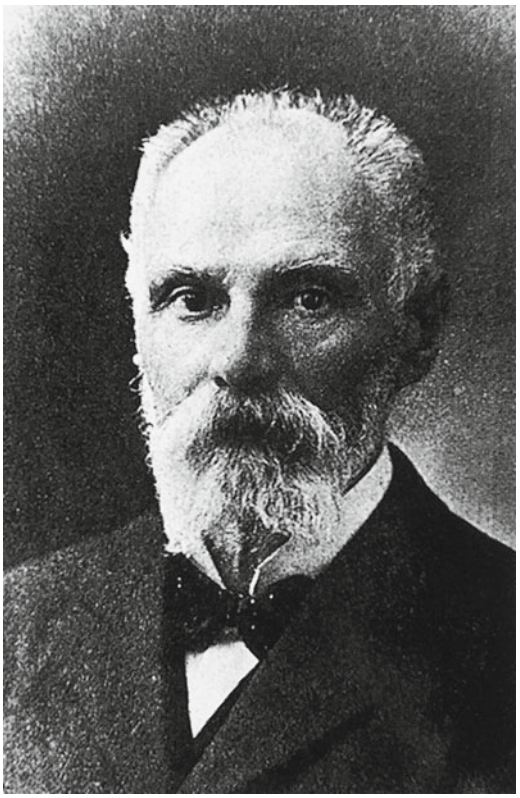

Fig. 1.18 Edoardo Bassini (1844–1924) invented the first successful inguinal hernioplasty

Bassini dissected the indirect sac and closed it off flush with the parietal peritoneum. He then isolated and lifted up the spermatic cord and dissected the posterior wall of the canal, dividing the fascia transversalis down to the pubic tubercle. He then sutured the dissected conjoint tendon consisting of the internal oblique, the transversus muscle, and the "vertical fascia of Cooper," the fascia transversalis, to the posterior rim of Poupart's ligament, including the lower lateral divided margin of the fascia transversalis. Bassini stresses that this suture line must be approximated without difficulty; hence the early dissection separating the external oblique from the internal oblique must be adequate and allow good development and mobilization of the conjoint tendon (Fig. 1.19).

The Bassini legacy was popularized by Attilio Catterina, Bassini's assistant in Padua in 1887 who later became professor in Genoa in 1904. Catterina was entrusted by Bassini to teach the exact surgical technique. To do this he wrote an atlas of "The Operation of Bassini!" This adds 16 life-sized color plates by the artist Orazio Gaicher of Cortina. This book was published in London, Berlin, Paris, and Madrid in the 1930s and described in detail the uncorrupted Bassini technique, especially the division of the transversalis fascia, resection of the cremaster muscle, and complete anatomical survey of all the relevant anatomy nowadays considered so essential [24, 25]—a foretaste of the Shouldice operation [26]. The illustrations show quite clearly that Bassini resected the cremaster muscle (Fig. 1.20) and completed division of

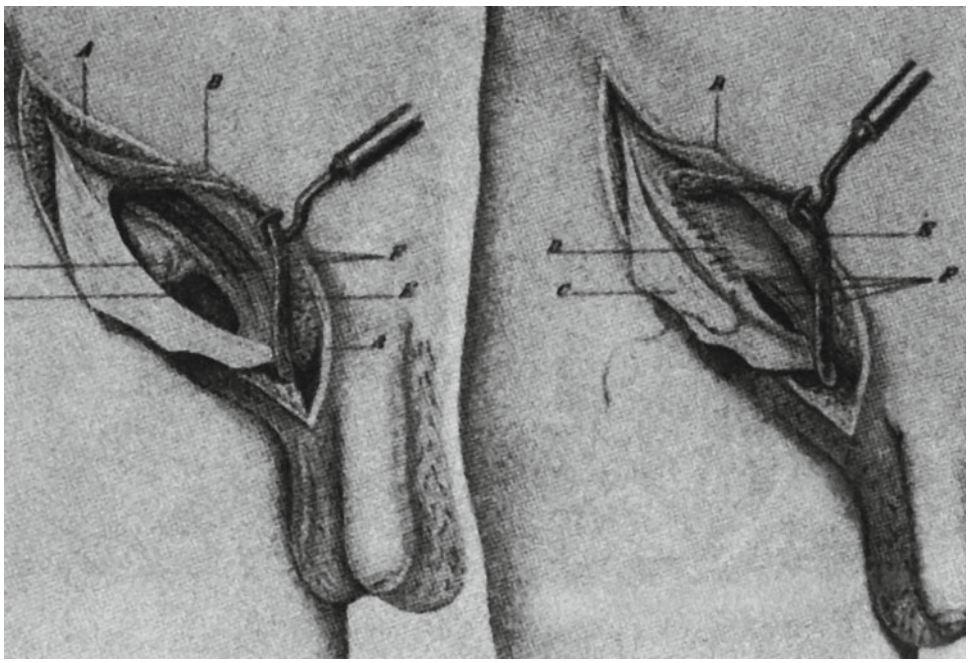

Fig. 1.19 Suturing the "triple layer" (F) (fascia transversalis, transversus tendon, and internal oblique) to the upturned edge of the inguinal ligament. An anatomical and physiological repair of the posterior wall of the inguinal canal preserving its obliquity and function (operation by Bassini in 1890 [20])

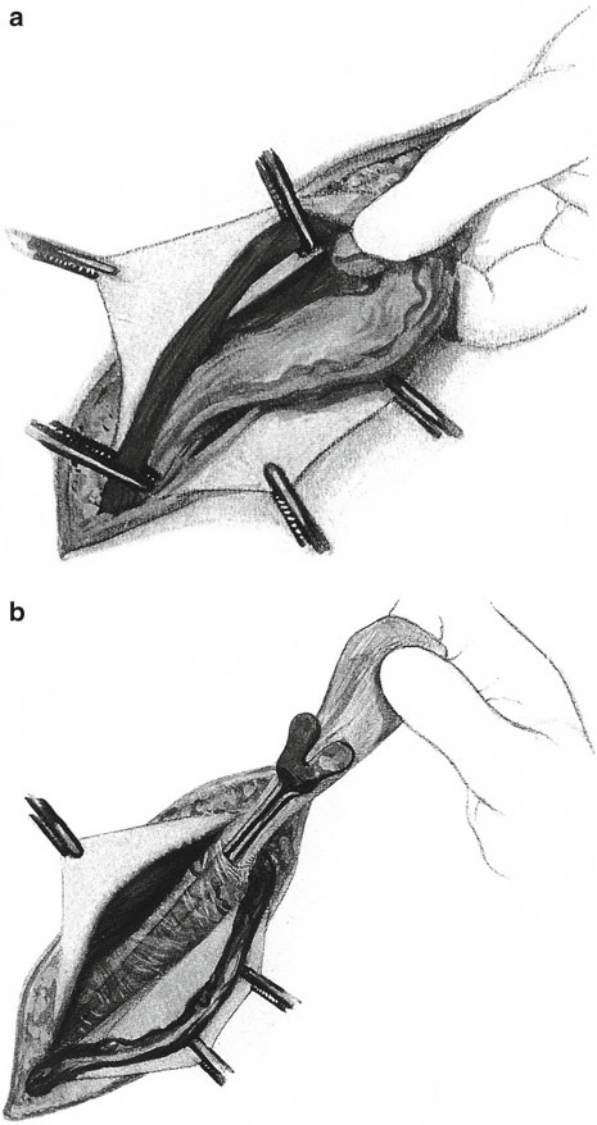

Fig. 1.20 (**a**) Bassini completely isolated and excised the cremaster muscle and its fascia from the cord. He thus ensured complete exposure of the deep ring and all the posterior wall of the inguinal canal, an essential prerequisite to evaluate all the potential hernial sites. (**b**) Bassini stressed the complete exposure and incision of the fascia transversalis of the posterior wall of the inguinal canal. To complete the repair he sutured the divided fascia transversalis, together with the transversus muscle, and the internal oblique muscle, "the threefold layer" to the upturned inner free margin of the inguinal ligament [24]

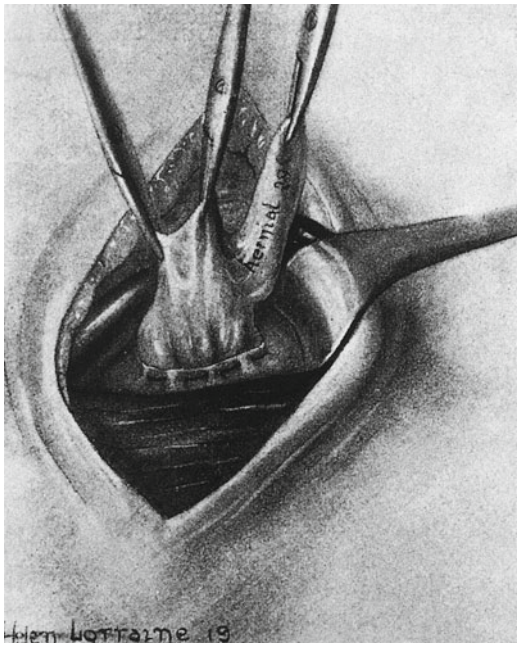

Fig. 1.21 Transabdominal approach to the groin through a muscle-splitting incision above the inguinal canal with subsequent closure of the peritoneal sac away from the canal [39]

the posterior wall of the inguinal canal (Fig. 1.21). The Shouldice and Bassini hernioplasties are therefore essentially the same.

By contrast, Haidenthaller, from Billroth's Clinic in Vienna, reported 195 operations for inguinal hernia, with 11 operative deaths and a short-term recurrence rate of 30.8% [22]. Although Halsted made important contributions to herniology, his general technical contributions of precise hemostasis, absolute asepsis, and the crucial importance of avoiding tissue trauma are easily overlooked. Halsted was always concerned to achieve optimum wound healing, and he not only practiced surgery but he experimented and theorized. His observation on closing skin wounds is best repeated verbatim: "The skin is united by interrupted stitches of very fine silk. These stitches do not penetrate the skin, and when tied they become buried. They are taken from the underside of the skin and made to include only its deeper layers—the layers which are not occupied by sebaceous follicles" [27, 28]. In today's world, hematoma, sepsis, and damaged tissue leading to delayed healing mean not only a poor surgical outcome but weigh heavily on the debit side of any economic evaluation. These Halstedian principles should be rigidly applied by any surgeon who undertakes hernia surgery.

Halsted must also be given priority for recognizing the value of an anterior relaxing incision, first described by Wolfler in 1892 [29] and subsequently popularized in the USA by Rienhoff [30] and in England by Tanner (1942) [31]. Apart from Halsted, countless other authors have corrupted or simplified the original Marcy–Bassini concept of a review of the posterior wall of the canal and the correction of any deficits in it, the reconstruction of the patulous deep ring for indirect herniation, and the repair of the stretched fascia transversalis in cases of direct herniation. Bull and Coley independently sutured the internal oblique and the aponeurosis over the cord [32, 33], whereas Ferguson (1899) advised against any mobilization of the cord and, therefore, any review of the posterior wall of the canal [34].

Imbrication, or overlapping, of layers was introduced by Wyllys Andrews in 1895 in Chicago [35]. Andrews confessed

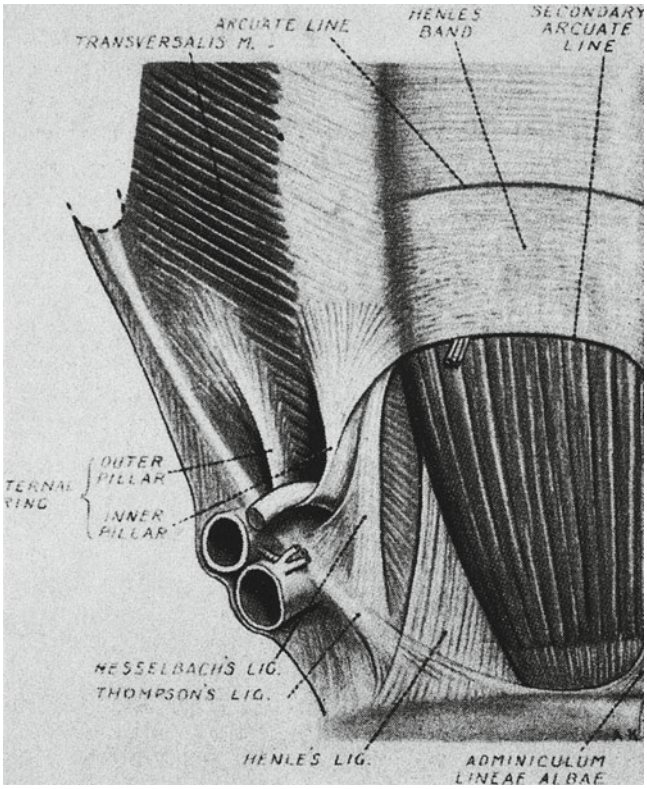

Fig. 1.22 The "shutter mechanism" of canal and the internal anatomy of the deep ring, demonstrating the sling of fascia transversalis which pulls the deep ring up and laterally when the patient strains [50]

that his technique was an outgrowth of experience with MacEwan, Bassini, Halsted and similar operations. Andrews laid great stress on careful aseptic technique: "Finally, I unite the skin itself with a buried suture which does not puncture any of its glands or ducts." Andrews used cotyledon only as a dressing. Again the importance of careful surgical technique is emphasized. Andrews stressed the importance of the posterior wall of the canal: "The posterior wall of the canal . . . is narrowed by suturing the conjoined tendon and transversalis fascia firmly to Poupart's ligament." Andrews recommended the kangaroo tendon introduced by Marcy. Andrews then reinforced the posterior wall with the upper (medial) margin of the external oblique aponeurosis, which he drew down behind the cord and sutured to Poupart's ligament. Andrews' intention was to interlock or imbricate the layers. The lower (lateral) flap of the external oblique aponeurosis was then brought up anterior to the cord. Andrews concluded his article: "Any successful method of radical cure must be a true plastic operation upon the musculo-aponeurotic layers of the abdominal wall. Cicatricial tissue and peritoneal exudate are of no permanent value." Andrews had visited Bassini in Padua on several occasions to acquaint himself with the revolutionary operation. However, in his future descriptions of the operation, Andrews failed to mention that Bassini had divided the posterior wall of the inguinal canal, and these erroneous observations were passed on to a generation of European and American surgeons because Catterina's atlas was not published in Europe until the 1930s. Andrews' description of Bassini's operation was therefore the only definitive description, and the classical Bassini operation became corrupted until it was reintroduced as the Shouldice operation in the 1950s.

Perhaps we should pause at about 1905 and summarize what empiricism had achieved thus far. First, all authors agree that division of the neck of the sac and flush closure of the peritoneum is imperative to success. Second, dissection of the deep ring with exploration of the extraperitoneal space to allow adequate closure of the fascia transversalis anterior to the peritoneum emerges as a cardinal feature. Marcy and Bassini stress the fascia transversalis repair, Halsted emphasized it, and Andrews' diagram suggests it. Ferguson did not examine the entire posterior wall but tightened the internal ring lateral to the emergent cord. All are agreed that the deep ring is patulous in indirect herniation, and consequently the fascia transversalis must be repaired. In the English literature, Lockwood in 1893 clearly emphasized the fascia transversalis and Bassini's "triple layer." Lockwood obtained good results by repairing this important layer [36, 37]. Third, preservation of the obliquity of the canal is suggested by Marcy and Bassini and by the later Halsted and Bloodgood papers.

Fourth, double breasting (imbrication) of aponeurosis gives improved results and is recommended by Andrews. Lastly, all the authors stress careful technique. Avoidance of tissue trauma, hematoma, and infection leads to impressively better results. Sepsis is an important antecedent of recurrence.

After the nineteenth-century advances of Marcy and Bassini and the important contribution to surgical technique by Halsted, little of major importance was contributed until the 1920s. Countless modifications of Marcy's and Bassini's operations were made and reported frequently. The Bassini operation reemerged as the Shouldice repair in 1950s (Fig. 1.22). Earl Shouldice (1890–1965) also promulgated the benefits of early ambulation and opened the Shouldice clinic, a hospital dedicated to the repair of hernias to the abdominal wall. A huge experience accumulated with an annual throughput of 7000 herniorrhaphies per year, enabled the surgeons at the Shouldice clinic to study the pathology in primary and recurrent hernias and to emphasize adjuncts to successful outcomes. Continuous monofilament wire was used in preference to other suture materials and the hernioplasty incorporated repair of the internal ring, the posterior wall of the inguinal canal, and the femoral region. The cremaster muscle and fascia with vessels and genital branch of genitofemoral nerve were removed, and the posterior wall after division was repaired by a four-layer imbrication method using the iliopubic tract as its main anchor point. The landmark publication

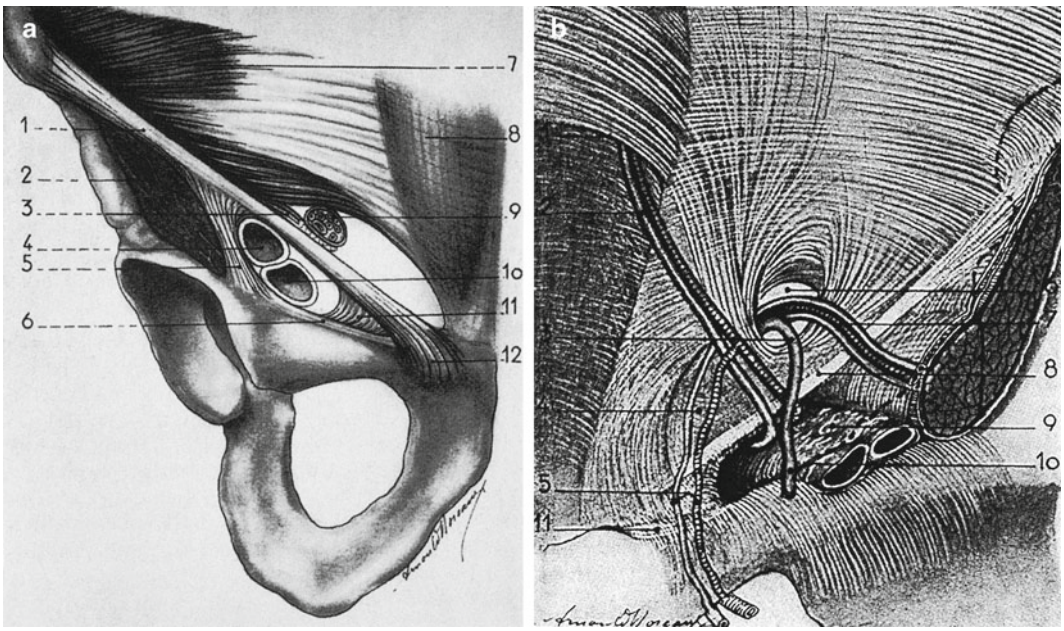

Fig. 1.23 (**a**) Fruchaud's concept of the myopectineal orifice ("'l'orifice crural classique") incorporating the inguinal and the femoral canals. An external view showing the two canals separated by the inguinal ligament and internal dissection (**b**) demonstrating how the muscles of the groin form a tunnel down to the myopectineal orifice [51]

with long-term follow-up was produced by Shearburn and Myers in 1969, and from this time until the introduction of mesh, the Shouldice operation became the gold standard for inguinal hernia repair [38].

The Extraperitoneal–Preperitoneal Approach to the Groin

Alternatives to the anterior (inguinal) approach to the internal ring include the transabdominal (laparotomy) [3, 39] and the extraperitoneal (preperitoneal) [40]. Marcy recognized the advantages of the transabdominal intraperitoneal approach to the ring in 1892:

> It may rarely happen to the operator who has opened the abdomen for some other purpose to find the complication of hernia. When the section has been made considerably large, as in the removal of a large tumour; the internal ring is within reach of the surgeon. Upon reflection, it would naturally occur to any operator that under these conditions it is better to close the internal ring, and reform the smooth internal parietal surface from within by means of suturing. My friend, Dr N. Bozeman of New York, easily did this at my suggestion in a case of ovariotomy more than 10 years ago.

Marcy attributed the transabdominal technique to the French in 1749 [41]. Lawson Tait recommended midline abdominal section for umbilical and groin hernia in 1891 [42]. LaRoque, in 1919, recommended transabdominal repair of inguinal hernias through a muscle-splitting incision about 1 in. (2.5 cm) above the ring. The peritoneum was opened, the sac dissected and then inverted into the peritoneal cavity by grasping its fundus and pulling it back into the peritoneal cavity. The sac was excised and a repair of the deep ring effected [39] (Fig. 1.23). LaRoque believed that the transabdominal approach provided absolute assurance of high ligation of the hernia sac and wrote three papers with accumulative experience of almost 2000 inguinal hernia repairs [43].

Battle, a surgeon at St Thomas' Hospital, London and the Royal Free Hospital, described his approach to repair of a femoral hernia in 1900. Battle pointed out the difficulties of diagnosing femoral hernia and the difficulties, principally the age, sex, and comorbidity, of managing patients with femoral hernia. He approached the hernia sac from above through an incision splitting the external oblique above the inguinal ligament. After dealing with the peritoneal sac, Battle repaired the femoral canal, constructing a "shutter" of the aponeurosis of external oblique which he sutured to the pectineus fascia and the pectineal ligament across the abdominal opening of the femoral canal [44, 45]. The Battle operation like many operations for groin hernia has now passed into oblivion.

The extraperitoneal–preperitoneal approach owes its origin to Cheatle (1920) who initially used a midline incision but subsequently (1921) changed to a Pfannenstiel incision [40, 45]. Cheatle explored both sides, and inguinal and femoral protrusions were reduced and amputated. If needed, for strangulation or adhesions, the peritoneum could easily be opened. The fascia transversalis was visible and easily repaired. Cheatle advised against this approach for direct

hernia because the direct region was usually obscured and distorted by the retraction of the rectus muscles. However, Cheatle's landmark contribution had a minimal impact at the time and remained little used for many years [43].

A.K. Henry, a master anatomist, rediscovered and popularized the extraperitoneal approach in 1936 [46]. At this time he was the Director of the Surgical Unit, Kasr-el-Aini Hospital, and professor of clinical surgery in the University of Cairo although he later returned to the Hammersmith Hospital and subsequently became professor of anatomy at the Royal College of Surgeons in Ireland. The full impact of the Cheatle/Henry operation was not recognized until after the Second World War, when McEvedy [47] adopted a unilateral oblique incision retracting the rectus muscle medially to approach a femoral hernia. In the USA, Musgrove and McCready (1949) adopted the Henry approach to femoral hernia [48]. Mikkelsen and Berne (1954) reported inguinal and femoral hernias repaired by this technique and commended the excellent access obtained even in the obese. Furthermore femoral, inguinal, and obturator hernias were all repairable through this "extended suprapubic approach" [49].

Two Europeans: Lytle and Fruchaud

In the immediate aftermath of the Second World War two European surgeon anatomists, Lytle and Fruchaud, are important contributors. Lytle was principally concerned with the anatomy and shutter mechanism of the deep inguinal ring. He dissected the deep ring and in a remarkable film demonstrated its prophylactic mechanism in indirect herniation. He was concerned to preserve the mechanism of the ring and at the same time to reinforce its patulous medial margin in indirect herniation. He emphasized that maneuvers which damaged the lateral "pillars of the ring" inevitably compromised the physiological shutter mechanism. In a subsequent study he clearly described the embryological anatomy of the ring and how it could be repaired in the fascia transversalis layer, without losing its function [50] (Fig. 1.24).

A remarkable Frenchman, Henri Fruchaud, published two books in Paris in 1956: L'Anatomie Chirurgicale de la Region de l'Aine (Surgical Anatomy of the Groin Region) [51] and Le Traitement Chirurgical des Hernies de l'Aine (Surgical Treatment of Groin Hernias) [52]. Fruchaud combined traditional anatomical studies of the groin, the work of Cooper, Bogros, and Madden, with his own extensive anatomical and surgical experience. He invented an entirely new concept—"the myopectineal orifice"—which combined the traditionally separate inguinal and femoral canals to form a unified highway from the abdomen to the thigh. The abdominocrural tunnel of fascia transversalis extended through this myopectineal orifice, through which all inguinal and femoral hernias pass, as do the iliofemoral vessels. Based on this anatomical concept

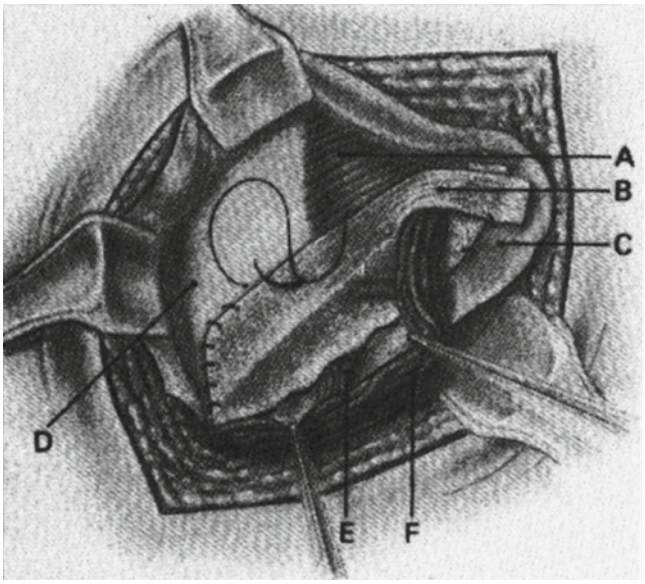

Fig. 1.24 The Lichtenstein's tension-free hernioplasty [150]

Fruchaud recommended complete reconstruction of the endofascial wall (fascia transversalis) of the myopectineal orifice. This unifying concept forms the basis for all extraperitoneal mesh repairs, open or laparoscopic, of groin hernias (Fig. 1.25). Fruchaud's two books were never published in English and therefore his findings remained relatively obscure and did not have the full impact and recognition until the laparoscopic era of hernia repair [53]. The concept of Fruchaud has been expanded by Stoppa in France and Wantz in the USA into the "giant reinforcement of the peritoneal sac" repairs of inguinal hernias [54, 55].

Inguinal Hernias in Soldiers in Georgian England

Hernias in England during the Georgian period of the early eighteenth century were prevalent amongst servicemen, typically recruited from amongst the malnourished. Civilian medical practice had deemed the rupture incurable taking a palliative approach. For the military, this was unacceptable; wastage rates due to ruptures were high and servicemen were valuable commodities. Treatment (experimentation) was a contentious activity relying on the whim of patronage and wartime budgets. Two clinical trials with war office funding were carried out between 1721 (Grenton) and 1770 (Lee) and were eventually exposed as ineffectual and "polemic doggerel and quackery."

The four major characteristics of eighteenth-century hernia treatment in Britain were as follows:

1. It was considered an unmanly ailment that questioned the virility and general health of the afflicted.

Fig. 1.25 Drs. Shulman, Lichtenstein, and Amid, pioneers at the Lichtenstein Clinic

2. Hernia was a chronic disorder only to be managed by palliative nonoperative procedures.
3. Most hernias were inguinal.
4. Afflicted males were poor and usually laborers.

In 1776 Dr George Carlisle reported biographical and autopsy details of an ex-serviceman, John Hollowday, who died of natural causes aged approximately 80 with a massive inguinoscrotal hernia stretching down to his knees. Such a hernia was apparently not an uncommon finding in ex-military men, and Hollowday had initially concealed the hernia "to avoid the scoffs of his companions." The hernia increased in size until Hollowday was adjudged unfit to serve, and he was admitted as an outpensioner to the Royal Hospital Chelsea in 1725 while still in his mid-thirties. Neglected hernias such as these can now only be found in third-world countries such as Africa.

Radical cures for hernia in the eighteenth century included escharotics (a caustic seal of the inguinal rings with scar tissue), castration (skin was used to close the opening), and trusses (after reduction of the hernia) which were of multiple types and military trusses were mass produced. To treat this massive problem of hernia, a rupture hospital (voluntary) was opened in Greenwich in 1756 but which only stayed open until 1765.

The exact number and rate of hernia occurrences in the Georgian British Army is unknown. However, the periodically malnourished, diseased, and constipated; occasionally physically overworked; and perpetually unfit British troops manning camps and barracks ringing with hacking smokers' coughs and a distinctive short consumptive bark may be a gross characterization, but we should not detract from the fact that the underlying causes of hernia were endemic characteristics of eighteenth-century soldiers and soldiering. To counter this debilitating disorder, the army required an efficacious cure that conventional therapeutics could not deliver. But, even though patronage was directly responsible for the establishment of a preferred treatment in a military hospital, the management of rupture slipped back into the margins of military and medical consciousness. The cure for inguinal hernia had to wait for at least another 100 years.

Winston Churchill's Hernia Repair

Schein and Rodgers reported an interesting vignette of Winston Churchill's hernia repair in 1947 [56]. On an early summer morning, June 11th in a small private nursing home on Berwick Street, London, within walking distance of Harley Street, the 73-year-old Winston Churchill had his inguinal hernia repaired by Thomas Dunhill who was only 2 years younger than his patient. Both elderly gentlemen, the patient and his surgeon, were rather short in stature, gray haired, and balding, but the patient was corpulent and stocky, and his surgeon was lean and agile.

Dunhill was described by his colleagues as "modest, courteous, professionally correct and of complete intellectual integrity." He was a master surgeon being appointed to the Royal household in 1928, and in 1930 as honorary surgeon to King George V and later to King Edward VIII and King George VI. In 1935 on his 60th birthday, Dunhill retired from the staff of St Bartholomew's Hospital and engaged in a flourishing private practice at No 54 Harley Street. He was born and educated in Australia and after qualifying in medicine came to London as first assistant to

Professor George Gask at the new professorial unit at the University of London at St Bartholomew's Hospital. In 1939 he was awarded an honorary FRCS England, the first time this title had been bestowed on a surgeon who was in active practice.

Winston Churchill first became aware of his hernia on September 5th, 1945, writing to his wife Clementine that he had recently ruptured himself and developed a painless swelling and would have to be fitted with a truss. He was consulted by Lord Moran, long-time president of the Royal College of Physicians who in turn consulted Brigadier Edwards the consulting surgeon for the army in Italy who advised that Churchill should buy a truss in Milan.

For almost 2 years, nothing was heard about Churchill's hernia until in June 1947; in Moran's diaries, it is reported that the hernia was now much larger, it had been increasingly difficult to control with a truss, and it was hardly ever out of his mind. Thomas Dunhill has been selected as the prospective surgeon.

Churchill's habits of smoking cigars and alcohol consumption were well known, and he undoubtedly suffered from chronic obstructive airways disease and obesity. The operation would therefore have been challenging.

On the morning of the operation, Churchill was found in bed reading loudly from Thomas Babbington McCauley's essays. The operation was performed under general anesthesia, presumably ether, and lasted for more than 2 h. The type of hernia and the method of repair were unknown, but the method was probably a type of Bassini procedure. Postoperative recovery was uneventful with the patient experiencing little discomfort.

Dunhill's herniorrhaphy proved successful and durable for Churchill's groin remained asymptomatic for the next 17.5 years until his death. Dunhill stopped operating in 1949 when he had only three patients left, "The King (George VI), Queen Mary, and Winston Churchill."

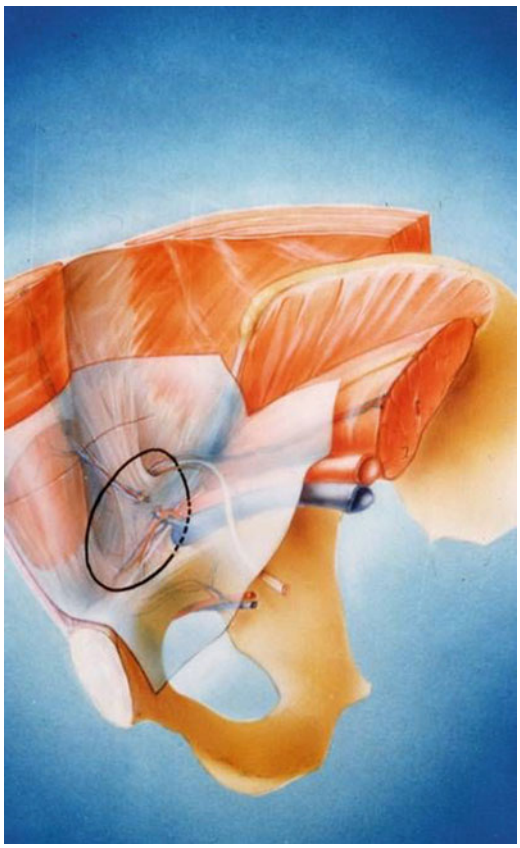

Fig. 1.26 Myopectineal orifice of Fruchaud

Tension-Free Hernia Repair

Irving Lichtenstein is the seminal thinker who introduced tension-free prosthetic repair of groin hernias into everyday, commonplace, outpatient practices. As well as being an office procedure under local anesthetic, Lichtenstein pioneered the idea that hernia surgery is special, that it must be performed by an experienced surgeon and cannot be relegated to the unsupervised trainee doing "minor" surgery. The key feature of Lichtenstein's technique is the "tensionless" operation. With his coworkers, Shulman and Amid, he has developed a simple prosthetic operation, which can be performed on outpatients [57, 58] (Fig. 1.26). As a pioneer, Lichtenstein worked hard to promulgate his ideas but even so the first edition of his book "Hernia Repair Without Disability" written in 1970 sold rather poorly and never went beyond the first printing [43]. Subsequent additions, however, required numerous reprints to meet demand paralleling the increase in popularity and worldwide success of the mesh-patch repair devised by Lichtenstein.

Laparoscopic Repair

Laparoscopic repair continues to develop its place in the surgical armamentarium of inguinal hernia. The use of the laparoscope has been extended to repair incisional, ventral, lumbar, and paracolostomy hernias. This latter technique is rapidly gaining in popularity.

The first attempt to treat an inguinal hernia with the laparoscope was made by P. Fletcher of the University of the West Indies in 1979 [59]. He closed the neck of the hernia sac. The first report of the use of a clip (Michel) placed laparoscopically to close the neck of the sac was made by Ger in 1982, who reported a series of thirteen patients: all the patients in this series were repaired

through an open incision except the thirteenth patient who was repaired under laparoscopic guidance with a special stapling device. The 3-year follow-up of that patient revealed him to be free of an identifiable recurrence. Ger continued his efforts to repair these hernias laparoscopically. He reported the closure of the neck of the hernia sac using a prototypical instrument called the "herniostat" in beagle dogs [60]. The results in these models appeared to be promising. In that same article, he reported the potential benefits of the laparoscopic approach to groin hernia repair as (1) creation of puncture wounds rather than formal incisions, (2) need for minimal dissection, (3) less danger of spermatic cord injury and less risk of ischemic orchitis, (4) minimal risk of bladder injury, (5) decreased incidence of neuralgias, (6) possibility of an outpatient procedure, (7) ability to achieve the highest possible ligation of the hernial sac, (8) minimal postoperative discomfort and a faster recovery time, (9) ability to perform simultaneous diagnostic laparoscopy, and (10) ability to diagnose and treat bilateral inguinal hernias. These potential advantages and advances in the laparoscopic repair of hernias continue to be the recognized goals that each method is attempting to achieve.

Bogojavalensky, a gynecologist, presented the first known use of a prosthetic biomaterial in the laparoscopic repair of inguinal and femoral hernias in 1989 [61]. He placed a roll of polypropylene mesh into indirect hernias of female patients. The neck of the internal inguinal ring was then closed with sutures. Popp repaired a coincidental direct hernia that was found at the time of a uterine myomectomy [62]. He recognized the need to provide coverage of a wider area than that of the defect itself. To accomplish this, he placed a 4×5-cm oval dehydrated dura mater patch over the defect. This was secured to the peritoneum with catgut sutures that were tied extracorporeally. Popp expressed concerns that the intra-abdominal repair of inguinal hernia could lead to adhesive complications and suggested that a preperitoneal approach might be preferable.

Schultz published the first patient series of laparoscopic herniorrhaphy in 1990 [63]. Rolls of polypropylene were stuffed into the hernial orifice, which was then covered by two or three flat sheets of polypropylene mesh (2.5×5 cm) over the defect. These rolls of mesh were not secured to either the fascia or peritoneum. To achieve access to the hernia defect, he incised the peritoneum. Following the placement of the rolls, he closed the peritoneum with clips. This probably represents the earliest attempt at a type of transabdominal preperitoneal (TAPP) repair that is commonly used today. Corbitt modified this technique by inverting the hernia sac and performing a high ligation with sutures or with an endoscopic stapling device [64]. Despite the initial success of these early reports, because of recurrence rates approaching 15–20%, these techniques were abandoned [65]. The lack of extensive dissection with the above methods, however, remained appealing. A similar concept was applied in the intraperitoneal onlay patch (IPOM) technique. Salerno, Fitzgibbons, and Filipi investigated this type of repair in the porcine model [66]. They placed rectangular pieces of flat polypropylene mesh to cover the myopectineal orifice and secured it with a stapling device. The success of these repairs led them to apply this method in clinical trials.

At about the same time, Toy and Smoot reported upon their first ten patients that were repaired with the IPOM technique [67]. They secured an expanded polytetrafluoroethylene patch (ePTFE) to the inguinal floor with staples that were introduced by a prototypical-stapling device of their own design, the "Nanticoke Hernia Stapler." They successfully used this fixation device in 20–30 patients without adverse results. A subsequent report of their first 75 patients was published in 1992 [68]. In this later series, the same prosthetic biomaterial (7.5×10 cm) was attached with the Endopath EMS® stapler. After a follow-up of up to 20 months, the recurrence rate was 2.4%. They noted a significant decrease in postoperative pain and an earlier return to normal activity as compared to the open repair of the hernia defect. Others reported similar results [69].

Fitzgibbons later abandoned the IPOM repair except for simple indirect inguinal hernias [70]. One patient developed a postoperative scrotal abscess that may or may not have been related to the placement of the mesh in that position. This patient was noted to have firm attachment of the appendix to the site of the polypropylene mesh. He also noted that, in follow-up of these patients, the patch material could be pulled into the hernial defect because it was affixed to the peritoneum alone rather than fascia. Because of these adverse events, he believed that the TAPP approach, which had been reported by Arregui [71] for inguinal hernia repair, was more appropriate. In this repair, the peritoneum is incised and dissected away from the transversalis fascia to expose the inguinal floor. The mesh material is then secured to that fascia which was believed to ensure superior fixation and tissue ingrowth. Both the TAPP and IPOM techniques require the entry into the abdominal cavity.

In a continuing effort to prevent bowel contact to the prosthesis, Popp described a method to dissect the peritoneum away from the abdominal wall prior to the incision of the peritoneum in the TAPP repair in 1991 [72]. Saline was inserted into the preperitoneal space with a percutaneous syringe. This "aquadissection" was found to be helpful in the dissection of this area to create a space in which to operate within the preperitoneal space. This early concept probably led to the idea that the entire dissection could be accomplished from within the preperitoneal space, thereby eliminating the need to enter the abdominal cavity.

Additional variations that did not gain acceptance were the "ring plasty" and a preperitoneal iliopubic tract repair. The former method was simply a sutured repair that approximated the deep structures of the lateral iliopubic tract to the proximal arching musculotendinous fibers of the transversus abdominis muscle [73, 74]. The latter technique was also a "tissue" repair but secured the iliopubic tract to the transversus abdominis muscle [75, 76]. This repair incorporated the use of an inlay of a prosthetic material but still had the disadvantage of being a repair under tension. These methods may have limited usage in rare circumstances.

In these earlier years, the predominant laparoscopic method of inguinal herniorrhaphy was the TAPP approach using either a polypropylene mesh or an expanded polytetrafluoroethylene material [72, 74, 77]. In 1992, Dulucq [78, 79] was the first surgeon to perform "retroperitoneoscopy" to effect a repair of an inguinal hernia without any direct entry into the abdominal cavity. In 1993, Phillips and Arregui separately described a technique that did not utilize a peritoneal incision in the repair of the inguinal floor [80, 81]. The dissection of the preperitoneal space was accomplished under direct visualization of the area via a laparoscope placed into the abdominal cavity. The laparoscope was then moved into the newly dissected preperitoneal space to complete the repair. Ferzli and McKernan later popularized the technique of Dulucq preferring the term "totally extraperitoneal" [82, 83]. Using the "open" entry into the preperitoneal space, the dissection of the space was carried out under direct visualization. This totally extraperitoneal (TEP) repair was identical to that of the TAPP but appeared to incur less risk of injury to the intra-abdominal organs.

Currently, the majority of laparoscopic inguinal hernia repairs are approached by either the TAPP or TEP method and utilize a polypropylene mesh biomaterial. The majority of the surgeons that perform the TEP repair utilize the commercially available dissection balloons to create the space within the preperitoneal area to perform the repair.

In a multicenter report, the recurrence rate of these repairs was 0.4% in 10,053 repairs with a median follow-up of 36 months [84]. The surgeons that continue to perform the laparoscopic herniorrhaphy believe that the goals that were anticipated by Ger have been realized.

The improvement in recovery in laparoscopic cholecystectomy patients and results that were seen in herniorrhaphy patients encouraged attempts to repair ventral and incisional hernias in 1991. The initial report by LeBlanc involved only five patients using an ePTFE patch biomaterial [85]. Although the overlap of the hernia defect by the prosthesis was only 1.5–2 cm, these patients were free of recurrence after 7 years of follow-up. The fixation used was that of the "box-type" of hernia stapler without the use of sutures. Sutures were used only to aid in the positioning of the patch. These sutures were removed from the prosthesis at the completion of the stapling of the patch. With further patients and follow-up, no recurrences were noted [86]. Barie proposed the use of a polyester material covered on the visceral side with a mesh of absorbable polyglactin [87].

Park modified the technique for the repair of large ventral hernias by utilizing the transfascial fixation of the ePTFE or Prolene® mesh with transabdominally placed Prolene® sutures passed through a Keith needle [88]. In their series of thirty cases, only one recurrence was noted. This repair used a fascial overlap of 2 cm. Holzman placed a Marlex® prosthesis with a 4 cm. overlap onto normal fascial edges and secured them with an endoscopic stapler [89]. He found this technique to be safe and effective. In separate investigations, Holzman, Park, and others compared the open versus laparoscopic methods and found that the laparoscopic repair was associated with fewer postoperative complications, a shorter hospital stay and lower recurrence rates than open prosthetic repair [89–93]. The largest study published to date confirms that the laparoscopic repair of incisional and ventral hernias can be accomplished with reproducibility and with excellent results [94]. Additionally, the long-term follow-up of LeBlanc's patients has proven that this is a durable procedure when the tenets that are noted below are applied.

1. A minimum prosthetic overlap of 3 cm.
2. Helical tacks placed 1–1.5 cm intervals.
3. Transfascial sutures placed at 5 cm intervals [85, 86].

Others, however, do not share this view. Some surgeons, notably in Spain, prefer the use of the "double-crown" technique [95, 96]. In this technique no sutures are used. Instead, two concentric rows of helical tacks are placed. The first is at the periphery of the biomaterial as in the sutured technique, and the second is inside of this one, near the hernia defect itself. The initial reports seem to have similar results as that of the authors using the transfascial sutures, but only a longer interval of follow-up will prove or disprove of either one or both of these approaches are the best.

Chronology of Hernia Surgery

Ancient	
1500 BC	Inguinal hernia described in an Egyptian papyrus. An inguinal hernia is depicted on a Greek statuette from this period [2]
900 BC	Tightly fitting bandages are used to treat an inguinal hernia by physicians in Alexandria. A Phoenician statue depicts this [2]
400 BC	Hippocrates distinguished hernia and hydrocele by transillumination [2]
AD 40	Celsus described the older Greek operations for hernia [97]
AD 200	Galen introduced the concept of "rupture" of the peritoneum allowed by failure of the belly wall tissues [2]
AD 700	Paul of Aegina distinguished complete and incomplete hernia. He recommended amputation of the testicle in repair [2]
Medieval	
1363	Guy de Chauliac distinguished inguinal and femoral hernia [4]
1556	Franco recommended dividing the constriction at the neck of a strangulated hernial sac [5]
1559	Stromayr published Practica Copiosa, differentiating direct and indirect hernia and advocating excision of the sac in indirect hernia [6]
Renaissance	
1700	Littre reported a Meckel's diverticulum in a hernial sac [98]
1724	Heister distinguished direct and indirect hernia [99]
1731	De Carengeot described the appendix in a hernial sac [100]
1757	Pott described the anatomy of hernia and of strangulation [9]
1756	Cheselden described successful operation for an inguinal hernia [7]
1785	Richter described a partial enterocele [101]
1790	John Hunter speculated about the congenital nature of complete indirect inguinal hernia [102]
1793	De Gimbernat described his ligament and advocated medial rather than upward division of the constriction in strangulated femoral hernia. This avoided damage to the inguinal ligament and the serious bleeding, which sometimes followed [103]
1804	Cooper published his three-part book on hernia—The plates are a tour de force; they are almost life sized and depict anatomy as never before. Cooper defined the fascia transversalis; he distinguished this layer from the peritoneum and demonstrated that it was the main barrier to herniation. He carefully delineated the extension of the fascia transversalis behind the inguinal ligament into the thigh as the femoral sheath and the pectineal part of the inguinal ligament—Cooper's ligament [10, 104, 105]
1811	Colles, who had worked as a dissector for Cooper, described the reflected inguinal ligament [106]
1816	Hesselbach described the anatomy of his triangle [107]
1816	Cloquet described the processus vaginalis and observed it was rarely closed at birth. He also described his "gland," so important in the differential diagnosis of lumps in the groin [108]
1846	Anesthesia discovered
1870	Lister introduced antiseptic surgery and carbolized catgut [11]
1871	Marcy, who had been a pupil of Lister, described his operation [17]
1874	Steele described a radical operation for hernia [109]
1875	Annandale successfully used an extraperitoneal groin approach to treat a direct and an indirect inguinal and a femoral hernia on the same side in a 46-year-old man. Annandale plugged the femoral canal with the redundant inguinal hernial sacs [110]
1876	Czerny pulled the sac down through the external ring, ligated it at its neck, excised it, and allowed it to retract back into the canal [14]
1881	Lucas-Championniere opened the canal and reconstructed it by imbrication of its anterior wall [111]
1886	MacEwan operated through the external ring; he rolled up the sac and used it to plug the canal [15]
1887	Bassini published the first description of his operation [91]
1889	Halsted I operation described [27]
1890	Coley's operation—placing the internal oblique anterior to the cord which emerged at the pubic end of the repair. This was the most pernicious and least effective corruption of Bassini's operation [33]
1891	Tait advocated median abdominal section for hernia [42]
1892	Wolfler designed the anterior relaxing incision in the rectus sheath to relieve tension on the pubic end repair and prevent recurrence at that site [29]
1893	Lockwood emphasized the importance of adequate repair of the fascia transversalis [36]
1895	W.J. Mayo—a radical cure for umbilical hernia [112]
1895	Andrews introduced imbrication or "double breasting" of the layers [35]
1898	Lotheissen used Cooper's ligament in repair of femoral hernia [113]
1898	Brenner described "reinforcing" the repair by suturing the cremaster between the internal oblique arch and the inguinal ligament. The fascia transversalis is not inspected. A serious corruption of the Marcy–Bassini strategy [114]

(continued)

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1899	Ferguson advised leaving the cord undisturbed—a more serious corruption of Bassini [34]
1901	McArthur darned his inguinal repair with a pedicled strip of external oblique aponeurosis [115]
1902	Berger turned down a rectus flap to repair inguinal hernia [116]
Modern Aseptic 1903	
1903	Halsted II operation. Halsted abandoned cord skeletonization to avoid hydrocele and testicular atrophy and adopted Andrews' imbrication and the Wolfler–Berger technique of a relaxation incision and a rectus sheath flap [117]
1906	Russell—the "saccular theory" of hernias, postulating that all indirect inguinal hernias are congenital [118]
1907	Kocher revised operation for indirect hernia without opening the canal. The sac was dissected, invaginated, and transposed laterally [16]
1909	McGavin used silver filigree to repair inguinal hernias [119]
1909	Nicol reported pediatric day-case inguinal herniotomy in Glasgow [120]
1910	Kirschner used a free transplant of fascia lata from the thigh to reinforce the external oblique [121]
1918	Handley reconstructed the canal using a darn/lattice technique [122]
1919	LaRoque—transperitoneal repair of inguinal hernia through grid iron (muscle-splitting) incision [39]
1920	Cheatle—extraperitoneal approach to the groin through a midline incision [40]
1921	Gallie used strips of autologous fascia lata to repair inguinal hernia [123]
1923	Keith—classic review of the causation of inguinal hernia. He remarked that aponeurosis and fascia are living structures and speculated that a tissue defect could be responsible for the onset of hernias in middle age [124]
1927	Keynes—surgeon to the London Truss Society—advocated elective operation using fascial graft techniques [125]
1936	Henry—extraperitoneal approach to groin hernia [46]
1940	Wakeley—a personal series of 2,020 hernias [126]
1942	Tanner popularized rectus sheath "slide" [31]
1945	Lytle reinterpreted the importance of the internal ring [127]
1945	Mair introduced the technique of using buried skin to repair an inguinal hernia [128]
1952	Douglas—first experimental studies of the dynamics of healing (aponeurosis) showed that aponeurotic strength was slow to recover and only reached an optimum at 120 days [129]
1953	Shouldice—a series of 8,317 hernia repairs with overall recurrence rate to 10 years of 0.8%. Emphasis on anatomic repair and early ambulation [130]
1955	Farquharson—an experience of 485 adults who had their hernias repaired as day cases [131]
1956	Fruchaud—the concept of the myopectineal orifice and fascia transversalis tunnel for all groin hernias [51]
1958	Marsden—a 3-year follow-up of inguinal hernioplasties. An important contribution to the evaluation of results [132]
1958	Usher—the use of knitted polypropylene mesh in hernia repair [133]
1960	Anson and McVay—classic dissections and evaluation of musculoaponeurotic layers based on a study of 500 body halves [134]
1962	Doran described the pitfalls of hernia follow-up and set out criteria for adequate evaluation [135]
1970	Lichtenstein showed the interdependence of suture strength and absorption characteristics with wound healing. Demonstrated experimentally the critical role of nonabsorbable or very slowly absorbable sutures in aponeurotic healing [136]
1972	Doran—critical review of short-stay surgery for inguinal hernia in Birmingham [137]
1973	Glassow reported 18,400 repairs of indirect hernia with a recurrence rate less than 1% [138]
1979	Laparoscopic hernia repair first attempted [59]
1981	Read demonstrated a tissue defect, metastatic emphysema, in smokers with direct herniation [139]
1981	Chan described patients developing hernia while undergoing continuous ambulatory peritoneal dialysis [140]
1983	Schurgers demonstrated an open processus vaginalis in a man 5 months after commencement on peritoneal dialysis [141]
1984	Gilbert described the umbrella plug for inguinal hernia repair [142]
1985	Read postulated an etiological relationship between smoking, inguinal herniation, and aortic aneurysm [143]
1986	Lichtenstein described the tension-free repair of inguinal hernias [144]
1989	Gullmo demonstrates the value of herniorrhaphy in patients with obscure symptoms in the groin or pelvis and to exclude primary or recurrent hernia [145]
1990	Robbins and Rutkow introduced the concept of a preformed mesh plug introduced into the hernia defect covered by a loose-lying mesh patch [146]
1990	Schultz first used a synthetic prosthetic biomaterial in the laparoscopic repair of an inguinal hernia [63]
1991	LeBlanc performs laparoscopic incisional hernia repair [147]
1992	Dulucq repairs an inguinal hernia laparoscopically without direct entry into the abdominal cavity [78]
1993	Environmental factors in hernia causation redefined [148]
1994	O Jeremy A Gilmore describes the surgical treatment of 1,400 sportsmen with groin disruption detailing the pathophysiology and treatment [149]

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