The Clinical Anatomy of Undescended Testis and Varicocele for Laparoscopic Management

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Undescended testis or cryptorchidism remains a common condition. It affects 1% of individuals[1] and is treated by pediatric surgeons, urologists, and general surgeons depending on the age of the patient, specialist services, and expertise available. Laparoscopy has been used for the localization of impalpable testis for more than 15 years. However, minimal access surgery has now made its impact in this field of surgery in terms of surgical intervention. It is used not only for the localization of undescended testis but also to perform laparoscopic orchidectomy[2] and both stages of the Foweler-Stevens orchiopexy.[3,4] Minimal access surgery is also used for the ligation of the testicular vein for varicocele.[5] The clinical anatomy of the undescended testis and varicocele is interrelated and therefore is dealt with in the same chapter, although there is no association between the two clinical conditions.

Videolaparoscopy and recent advances in investigations performed preoperatively to locate the undescended testis have increased the perception of clinical anatomy. Figures 1 through 4 show the anatomy in some of the investigations performed to locate the undescended testis. Figures 5 through 12 show the anatomy seen during laparoscopic orchidectomy.

NORMAL TESTIS, EPIDIDYMIS, AND SPERMATIC CORD

The normal testis is oval in shape and measures about 3.7 cm x 2.5 cm. It is covered by the tunica albuginea. The posterior part of the testis, where blood vessels enter and leave the testis and the efferent ducts leave the testis, is called the mediastinum of testis. Each testis is invaginated by a double serous covering. The latter is called the tunica vaginalis. The epididymis is attached to the posterolateral surface of the testis and is divided into head, body, and tail. The recess between the epididymis and testis on the lateral side is called the sinus epididymis. The epididymis is covered by the tunica vaginalis except at its posterior margin. The testis has a small stalked body at its upper extremity called the appendix testis, a remnant of the upper end of the paramesonephric (Mullerian) duct. The epididymis has also a stalked body at its upper end called the appendix epididymis (hydatid of Morgagni) which is a remnant of the mesonephros. As these structures are stalked, they are liable to undergo torsion.

From the attachment of the epididymis to the testis, fibrous septa radiate and reach the tunica albuginea. These septa divide the testis into approximately 400 spaces. Each space contains two to four seminiferous tubules. Each tubule is 60 cm long. The seminiferous tubules open into the rete testis which is a plexus of intercommunicating tubules. Fifteen to 20 vasa efferentia emerge from the rete and enter the head of the epididymis, which is formed by these convoluted efferent ducts. The latter fuse to form a convoluted single tube which forms the body and tail of the epididymis.

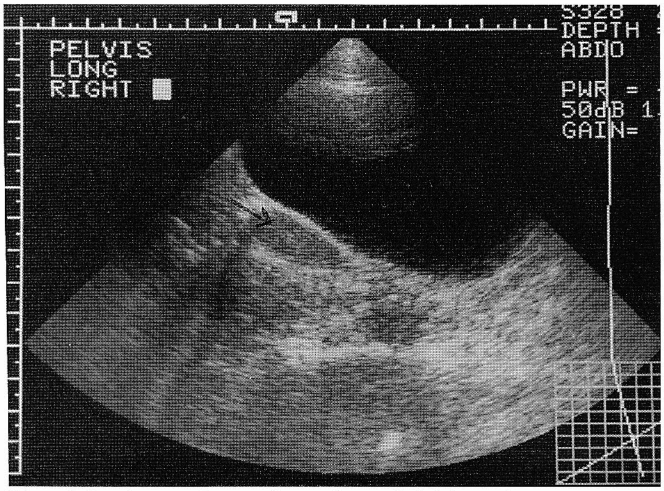

Figure 1. An ultrasound scan of an undescended right testis.

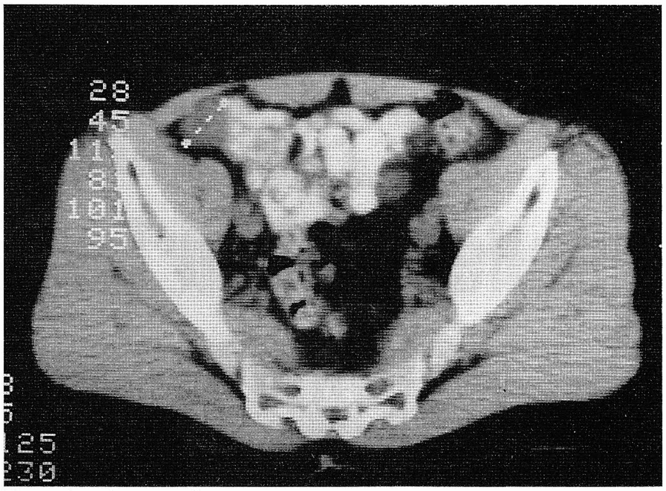

Figure 2. A CT scan of an undescended right testis.

The tail of the epididymis continues as the vas deferens, which travels across scrotum and inguinal canal before it reaches the side wall of pelvis via the internal ring as a retroperitoneal structure. It then heads towards the ischial tuberosity before turning medially towards the base of the bladder. It joins the seminal vesicle to form the ejaculatory duct. The latter traverses the prostate to open into the prostatic urethra. There are two seminal vesicles, one on each side, placed extraperitoneally. They lie at the base of the bladder lateral to the termination of the vas deferens.

Ellis[6] has described a simple way of remembering the components of the spermatic cord: (a) 3 layers of fascia (external spermatic, cremasteric, and internal spermatic); (b) 3 arteries (testicular, cremasteric, and artery to the vas); (c) 3 nerves (sympathetic fibrous, ilioinguinal nerve, and the nerve to cremaster from the genitofemoral nerve); and (d) 3 other structures (vas deferens, pampiniform plexus, and lymphatics).

The testicular artery arises from the abdominal aorta slightly below the origin of the renal artery, and it is the main blood supply to the testis and epididymis. There is also an artery to the vas (deferential artery)[7] which arises from the inferior vesical branch of the internal iliac artery. After it leaves the pelvis, it mainly supplies the vas and epididymis. The testicular artery anastomoses with the deferential artery. Furthermore, the testicular artery and deferential arteries also anastomose with the cremasteric arteries and anterior and posterior scrotal arteries which supply the coverings of the testis. Due to cross connections described, the ligation of the testicular artery may not necessarily lead to testicular atrophy. The venous drainage of the testis and epididymis is described along with the clinical anatomy of varicocele.

The lymphatics of the testis and epididymis drain along with the contents of the spermatic cord. After leaving the internal ring, they follow the testicular vessels and join the upper lumbar nodes. As a consequence, testicular tumors metastasize to the para-aortic lymph nodes close to the renal vessels rather than the inguinal nodes.

As the testis descends, it carries not only its blood supply with it but also its nerve supply. The connector cells of the sympathetic nerves lie in the tenth thoracic segment of the spinal cord. The efferent fibers pass in the greater and lesser splanchnic nerves to the celiac ganglion where they synapse. Postganglionic fibers travel along the testicular artery and reach the testis. The sensory fibers for testicular sensation share the same sympathetic pathway. Testicular pain may thus radiate to the loin and renal pain may be referred to the scrotum.

TESTICULAR DESCENT

The testis originates in the abdomen just below the renal level and moves caudally. This migration is referred to as testicular descent. The reason for which the testis descends is still a mystery, though there are several theories.[8] None of them offers conclusive evidence and all of them may have a role.

The testis lies posterior to the parietal peritoneum and therefore its descent is also retroperitoneal. In the earlier stages of development, it is connected to the inguinal region by the genitoinguinal ligament.[7] The latter is a condensation of connective tissue. This ligament becomes thicker once the testis reaches the inguinal canal. It is then called the gubernaculum (helm or rudder) testis. John Hunter[9] proposed the traction theory, dependent on the concept that the gubernaculum (Fig. 7) pulls the testis into scrotum. According to the differential growth theory, the testis is kept in proximity to the internal inguinal ring; it is pulled into the scrotum by the relatively immobile gubernaculum as a result of rapid growth of the body wall during the last trimester of pregnancy. The intra-abdominal pressure theory of testicular descent suggests that an increase in the intra-abdominal pressure is the primary force that causes the testis to leave the abdomen and enter the inguinal canal. The epididymal theory of testicular descent is based on the assumption that differentiation and maturation of the epididymis induces testicular descent. According to the endocrine theory, an abnormality in the hypothalamic-pituitary-testicular axis results in undescended testis. Lockwood (1856-1914) postulated the theory of many gubernacular tails,[10] suggesting that in ectopic testis the scrotal tail becomes ruptured. As a result, the testis follows one of the accessory rudders and ends up in an abnormal position.

Along with the descent of the testis, all the layers of the abdominal wall deep to the superficial fascia protrude into the scrotum to form inguinal bursa which forms tunica (covering or coat) of testis and spermatic cord. The gubernaculum is attached to the floor of the inguinal bursa. It appears that the testis follows gubernaculum into the scrotum for reasons not understood. The migration of testis to scrotum is usually completed by the eighth month of fetal life.

UNDESCENDED TESTIS

If the testis does not descend normally, it leads to an undescended or ectopic testis. The undescended testis (Fig. 5) is located either on the posterior wall of the abdominal wall, the pelvic cavity, or in the inguinal canal and does not emerge through the superficial inguinal ring. The ectopic testis emerges through the superficial inguinal ring and may be found,[10] in order of frequency, (1) anchored in the superficial inguinal pouch, (2) in the perineum, (3) at the root of the penis, (4) or in the femoral triangle. In contrast to the undescended testis, the ectopic testis often develops well, if not fully. The scrotum is usually not well developed when there is an abnormality in the descent of the testis.

A retractile testis is due to spontaneous or provoked activity of the cremaster muscle. Farrington[11] reported that below the age of 12 years, up to 20% of children have retractile testes, but after the age of 13 years the condition is rare. The anatomical and physiological reasons for the disappearance of this protective reflex are not known. It is important to differentiate between retractile and undescended testes to avoid errors in the calculation of incidence of undescended testis. The incidence of undescended testis in pre-term infants is 30.3% in comparison with 3.4% in full-term infants. In 1-year-old children, the incidence is 0.8% and in adulthood it remains the same.[8]

The processus vaginalis which connects the peritoneal cavity to the tunica vaginalis closes between the eighth month of fetal life and the first month after birth. However, if testis does not descend normally, the processus vaginalis remains patent. This may present clinically as a hernia or a hydrocele. A small hernia sac is found in the majority of patients with undescended testis (Fig. 5). When the undescended testis is associated with a patent processus vaginalis, 71% of patients have an epididymal abnormality.[12]

PATHOLOGICAL EFFECTS

The scrotum is relaxed when the environmental temperature is warm and is contracted by the involuntary dartos muscle when it is cold. An undescended testis is kept at a higher temperature (1.5 to 2° C) which affects spermatogenesis. If the testis has not descended by the age of 5 years, spermatogenesis is severely affected. The higher the distance of the testis from the scrotum and the longer the duration for which it has remained so will determine the severity of deranged spermatogenesis. Histological derangements can occur by 18 months after birth. This is the main reason for surgical correction around 2 years of age when the testis is near the superficial inguinal ring without any hope for natural descent.

The undescended testis has a 40 times higher chance of becoming malignant than the normal organ.[13] Ten percent of testicular tumors originate from an undescended testis. An abdominal testis is four times more likely to undergo malignant change than an inguinal testis.[14] Malignant change occurs usually at puberty or after, although it can occur in infants. Approximately 2% of patients with undescended testis have carcinoma in situ and therefore testicular biopsy is recommended.[15] Twenty percent of the tumors in these patients arise from the descended testis due to reasons which are not clear. When both the testes are undescended and one of them develops malignant change, the other testis has a 15% chance of developing a tumor. An undescended testis can undergo torsion and the patient may present with abdominal pain. Majority of these patients have germ cell tumors. In view of the potential for malignant change, all impalpable testes are removed or repositioned in a palpable location.

INVESTIGATIONS

Once the testis is clinically not palpable, the choice of investigations to be performed is controversial and variable.

Figure 3. Testicular venography of a normal descended right testis.

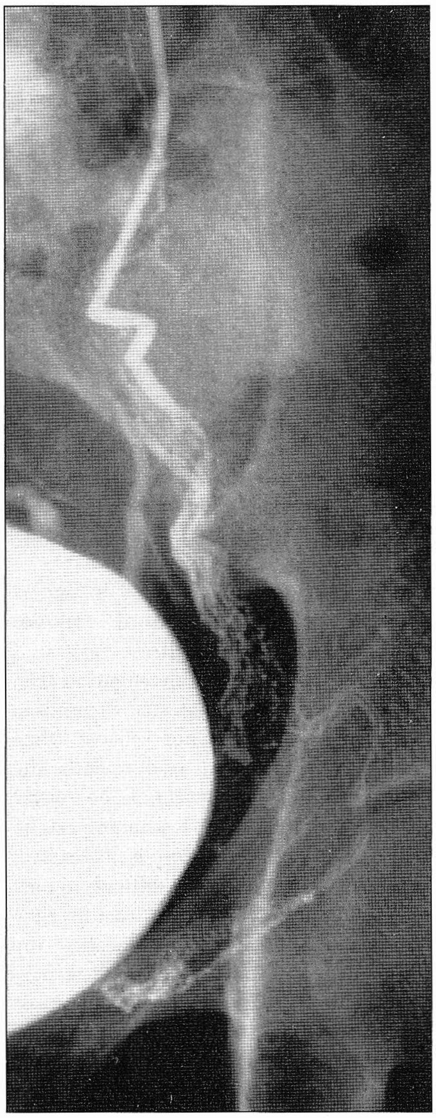

Figure 4. Testicular venography of an undescended left testis.

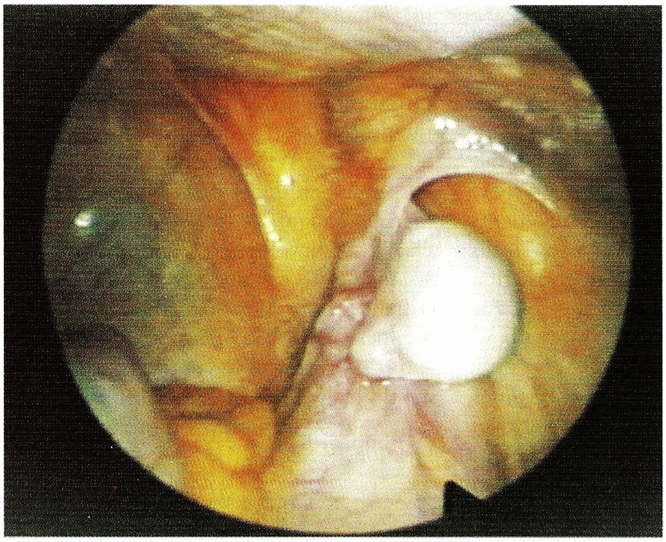

Figure 5. Laparoscopic overview of undescended intra-abdominal testis. Note the congenital hernia sac.

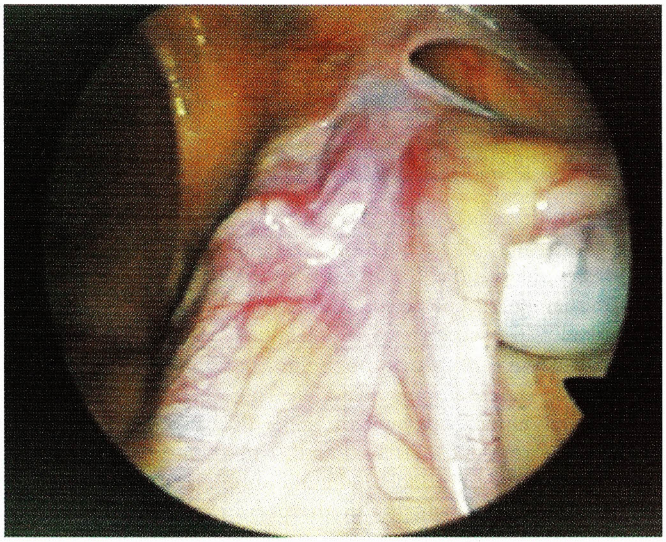

Figure 6. Vas deferens passing medially from an undescended intra-abdominal testis.

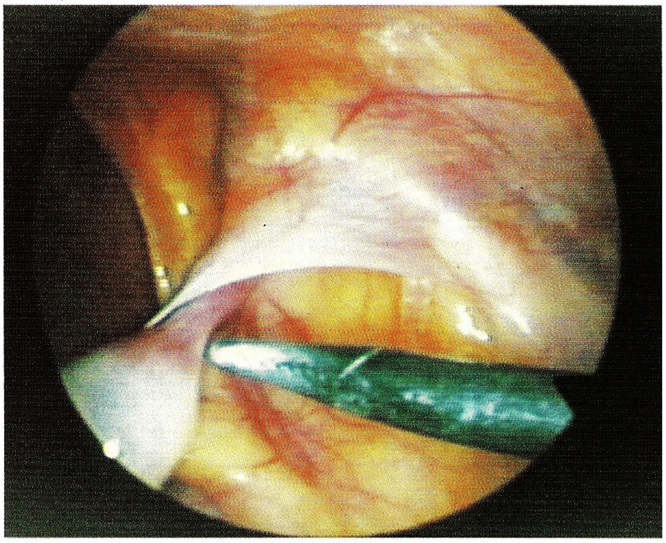

Figure 7. Gubernaculum of an undescended testis attached to the internal inguinal ring.

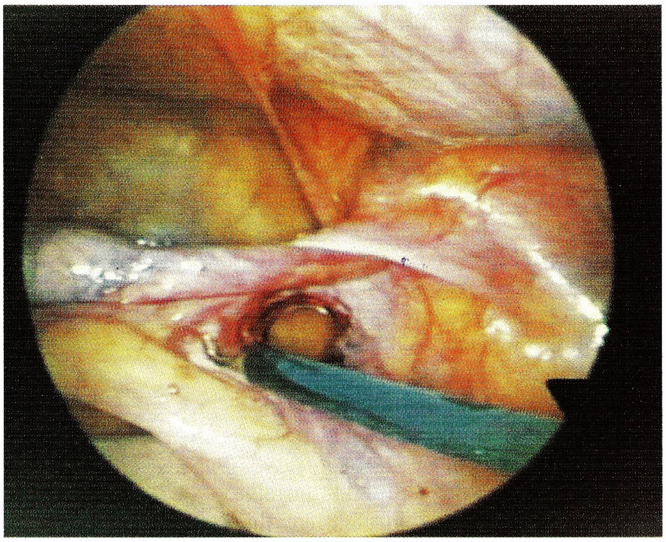

Figure 8. The gubernaculum is being freed from the posterior abdominal wall during laparoscopic orchidectomy.

However they can be valuable in understanding the clinical anatomy. Herniography is outdated now. Ultrasound scan is a commonly performed investigation (Fig. 1) helpful in locating the testis when it is in the inguinal canal but not reliable when the testis is located underneath the aponeurosis of the external oblique muscle or is intra-abdominal. CT scanning can be useful (Fig. 2) but the test is expensive, emits radiation, and can be difficult to perform in children. MRI is the least invasive test that may be helpful in locating the testis but, like CT, can be difficult to perform in children. Angiography is the most invasive test and can have major complications such as femoral thrombosis.

Testicular venography (Figs. 3, 4) can be a safe procedure in expert hands but is still invasive. When the pampiniform plexus is present, it presumes that the testis is present. Its main drawback is that when the pampiniform plexus is absent or when the testicular vein is blind-ending, one cannot be certain that the testis is absent. In one of our patients with impalpable testis, the ultrasonography did not show testis, but testicular venography suggested the presence of testis in the right side of scrotum. He subsequently underwent exploration of the scrotum to remove the atrophic testis. These patients may sometimes have an associated pathology. One of our patients was a 58-year-old man who presented with right gynecomastia. On clinical examination he was found to have a right undescended testis. An ultrasound scan of the abdomen and inguinal canal to look for the testis did not show a testis but did show an aortic aneurysm of 6 cm in diameter which influenced the management!

LAPAROSCOPY AND SURGICAL INTERVENTION

After performing a routine laparoscopic inspection of the peritoneal cavity, one should inspect the inguinal region on the normal side as a guide to the abnormal side. One should look for the testis, testicular vessels, and vas deferens (Figs. 5, 6). However, it is not always easy to locate the testis when it is rudimentary or absent. The spermatic cord structures are an important guide to the location of the testis. After passing the telescope, the outcome could be one of the following[16]:

1. Absence of the testis above the internal ring characterized by the blind-ending vas

and spermatic vessels. This could be due to an absent testis or very rudimentary testis or to an intra-abdominal vascular event which had led to atrophy of testis.

2. Normal or atrophic spermatic cord structures going into an inguinal ring. Occasionally it may be possible to pass the telescope into the inguinal canal and inspect. However, most of these patients need inguinal exploration. In 15% a testis is found which would be a good candidate for orchiopexy. In 85% of these patients, a nubbin of testicular tissue is found.[17] In 15% of such testicular nubbins, viable tubular structures are seen. The vas deferens in the normal situation has a shiny appearance; it is seen to rise out of the pelvis and cross the external iliac vessels to join the gonadal vessels. These vessels are identified as they run sagittally in the lateral retroperitoneum. The vas deferens and the spermatic vessels normally meet as a "V" and pass together into the inguinal canal via the internal inguinal ring. A similar relationship may be seen in intra-abdominal testis when the testis is near the internal ring (Fig. 6).

3. The presence of an intra-abdominal testis. The size of the testis, abnormal appearance of the testis, age of the patient, patient's choice and attitude towards testicular prosthesis, the surgeon's belief, normality of the opposite testis, fertility of the patient, the distance of the testis from the internal ring and the length of the vascular pedicle all influence the management. The surgical options available are as follows: orchidectomy, orchiopexy, first stage of a Foweler-Stevens orchiopexy (clipping the spermatic vessels), a standard Foweler-Stevens orchiopexy, or a planned staged orchiopexy. All these procedures can now be performed by laparoscopy.[2,3,4] Most of these procedures require an infraumbilical port for passing the telescope and right and left lateral ports for laparoscopic dissections.

The anatomy seen during an illustrative laparoscopic orchidectomy are shown in Figures 5 through 12. The first stage of a Foweler-Stevens orchiopexy involves clipping the spermatic vessels. The second stage of Foweler-Stevens orchiopexy involves mobilization of a wide pedicle around the intra-abdominal testis, formation of a new inguinal canal along the processus vaginalis, a 1-cm scrotal incision

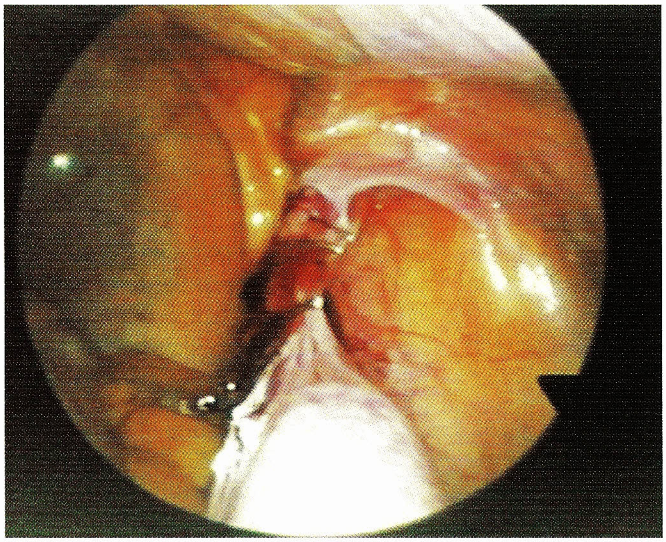

Figure 9. The gubernaculum is clipped before transection to release the undescended testis from the internal ring.

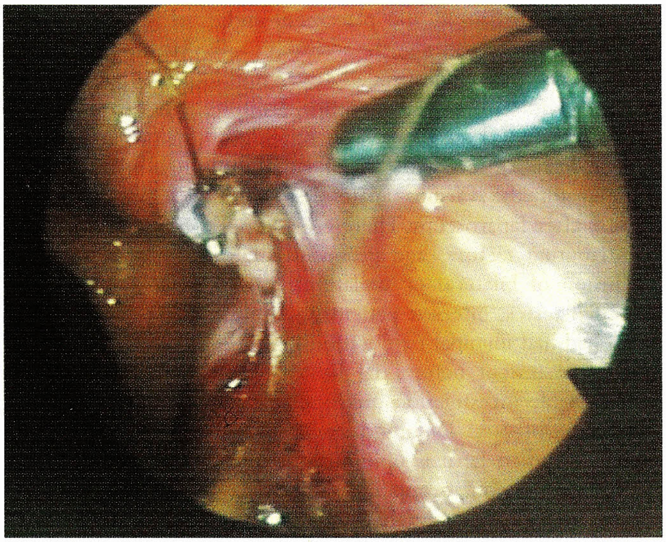

Figure 10. The congenital hernia sac associated with an undescended testis is everted and an endoloop is being passed around it in performing herniotomy.

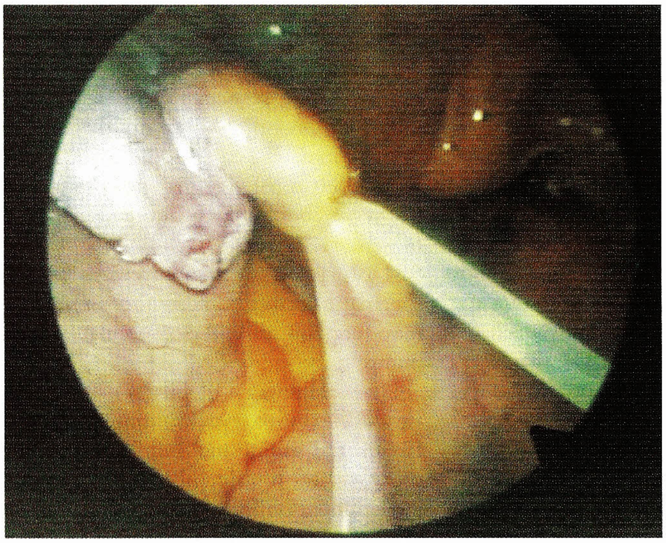

Figure 11. Endoloop is passed around the spermatic cord of the undescended testis before transection. It is safer to use two endoloop ligatures for good hemostasis.

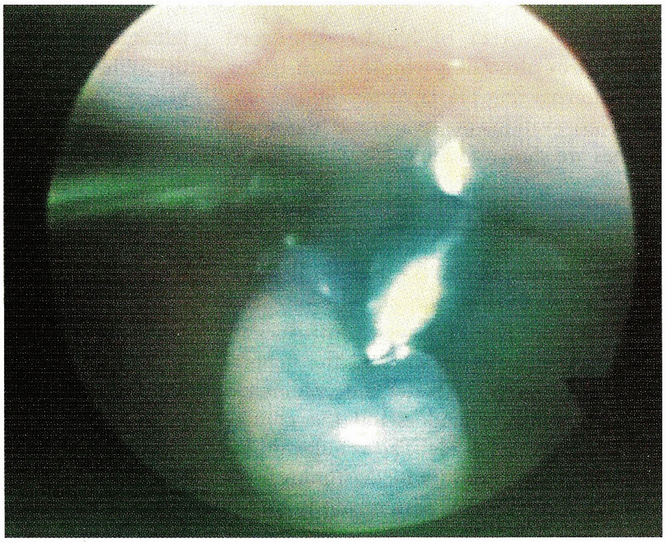

Figure 12. After laparoscopic orchidectomy, the spermatic cord is pulled out through the port and the testis is brought near the port site before it is pulled out.

Table 1. The anatomical outcome after diagnostic laparoscopy for undescended testis

Reference	Patients (N)	Testes (N)	Anatomical outcome(%)		
			Blind-ending	Intra-abdominal	Inguinal
Boddy et al.[18]	46	55	53	34	13
Bloom and Semm[19]	75	86	42	31	27
Guiney et al.[20]	86	103	38	51	11
Caldamone and Diamond[16]	104	106	59	22	19

for pouch formation, and placement and anchoring of the testes in the scrotum.

Patients with undescended testis may be dealt with by pediatric surgeons, urologists, or general surgeons. The reported series have differed in the frequency quoted for the various anatomical outcomes after laparoscopy. There are several contributing factors: age group studied, inclusion of bilateral or unilateral undescended testes, intersex patients, patients who had had inguinal exploration or hormonal treatment before the laparoscopy and variable investigations performed before laparoscopy. Diamond and Caldamone[16] studied laparoscopic observations in a homogeneous group but their study group included mainly the pediatric age group. The median age of their cohort was 2 years. However, they have made useful anatomical observations regarding cord structures. They have shown a left predominance (4:1) of blind-ending cord structures often in a whitish patch below the internal ring. The laparoscopic anatomical observations made in some important series are shown in Table 1.

VARICOCELE

Celsus described varicocele in the first century AD. However, its etiology and management have remained controversial. It is pertinent to understand the normal venous drainage of testis and epididymis before trying to understand the clinical anatomy of varicocele. The venules draining the testis reach its mediastinum from which several veins pass upwards in the spermatic cord. These veins surround the testicular artery. They also have extensive intercommunicating veins. This network of veins is called the pampiniform plexus. However, it joins to form two testicular veins in the inguinal canal which subsequently unite into one vein at the deep inguinal ring. This vessel usually passes proximally adjacent to the testicular artery on the psoas muscle. The right testicular vein joins the inferior vena cava and the left testicular vein joins the renal vein. The testicular veins are provided with valves only near their termination and not infrequently these valves are absent especially on the left side.[21] They may be found near the renal veins.

The venous system of the testis includes four main components[22]: (a) the cremasteric vein, which drains into the inferior epigastric vein and subsequently to the external iliac vein; (b) the deferential vein, which drains into the superior or inferior vesical vein; (c) the testicular vein, which drains into the left renal vein on the left side and into the inferior vena cava on the right side; (d) the external pudendal vein which drains into the great saphenous vein. The latter drains into the femoral vein. The former two veins (a and b) are less important and are collaterals while the latter two (c and d) are important drainage systems. In a normal subject, the pampiniform plexus contains minimal sinuses and it is mainly made up of intercommunicating veins. The diameter of these veins usually does not exceed 2 mm. The diameter of the testicular vein is also approximately 2 mm.

Varicocele is a state of varicosity of the testicular veins. There is retrograde flow of blood in the testicular vein. The pampiniform plexus is formed of multiple venous sinuses and is three times larger than in normal men. The veins are dilated and tortuous and the size of the vein[22] reaches a diameter of 5 mm. However, they coalece to form the testicular vein which is the main route of drainage. The next main route of drainage is the external pudendal vein, which arises from the plexus at the level of the inferior pubic ramus. After ligation of the testicular vein by laparoscopy, the main route of drainage is via the external pudendal vein. It passes laterally and terminates in the great saphenous vein which drains into the femoral vein. The cremasteric vein is a small vein and is an inconstant finding. It arises at the level of the superior pubic ramus. It passes laterally and superiorly to drain into the inferior epigastric vein or external iliac vein. There is no varicosity of the cremasteric vein. It was thought earlier that varicosity could exist in the cremasteric vein and its ligation could be successful in the treatment of varicocele. However, it has been shown[22] that this vein is not varicose and is an inconstant finding in patients with varicocele. The deferential vein is a small vein that originates near the testis and traverses upwards to reach the radicles of the internal iliac vein.

The left side is affected in 95% of patients. It is thought to be due to the left testicular artery arching over the left renal vein or abnormal angulation of testicular vein at its entry into the left renal vein. Different etiological factors have been suggested by several authors:

1. An increased incidence of absence of valves in the left testicular vein compared with the right.[21]
2. The left testicular vein is 8 to 10 cm longer than the right. It therefore acts as a longer hydrostatic column than the right, with an increased pressure in the upright position.[23]
3. The loaded sigmoid colon may compress the left testicular vein, leading to increased pressure, distal to the site of obstruction.[24]
4. The left renal vein may be compressed between abdominal aorta and superior mesenteric artery.[25]
5. Disturption of the coverings of the spermatic cord (e.g., hernia repair), which may function as a fasciomuscular venous pump.[26]

The old theory of bilateral effects of varicocele due to cross communication between the right and left pampiniform plexuses and transfer of substances (catecholamines, renin, and prostaglandin) to other side is no longer accepted. There is no intercommunication[22] between the left and right pampiniform plexuses in the scrotal, retropubic or pelvic regions. The accepted theory now is that the dilated venous system on one side can increase the intrascrotal temperature and affect both testes.

Operative intervention for varicocele is indicated when it is associated with oligospermia or pain. In conventional surgery there are two approaches. The high approach involves ligation of the testicular veins at the internal ring, and the low approach involves ligation of varicosities by a scrotal incision. Laparoscopic varicocelectomy involves ligation of the testicular vein at the internal ring with preservation of the testicular artery and vas deferens. The results of conventional and laparoscopic ligation of the testicular vein for varicocele are comparable. Venous reflux tested by C. W. Doppler disappears both after laparoscopic and conventional high ligation.[5] After ligation of the testicular vein for varicocele, the external pudendal vein becomes the most dominant drainage system. It is important to perform a routine laparoscopy before ligation of testicular vein. Left renal tumors obstructing the left renal vein can also give rise to left varicocele. A varicocele secondary to left renal tumors does not decompress in the supine position. **STI**

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