ALMA MATER STUDIORUM
UNIVERSITY OF BOLOGNA, ITALY

Academic Master in:

‘‘Minimally Invasive and Robotic Pediatric Surgery’’

Pediatric Surgery Department - Bologna

Thesis title

‘Laparoscopic orchiopexy for palpable undescended testes: systematic review and meta-analysis’

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Academic year
2019-2020

CONTENTS

SUMMARY (ABSTRACT)

Laparoscopic orchiopexy for palpable undescended testes: systematic review and meta-analysis

Background: It has recently been claimed that laparoscopic orchiopexy (LO) is superior to open orchiopexy (OO) for palpable undescended testes.

Purpose: To investigate the outcomes of LO of palpable undescended testes in relation to high retroperitoneal dissection, Prentiss maneuver and intrascrotal testis fixation. To identify evidence for the safety, efficacy and cost of LO compared with OO in palpable undescended testes.

Methods: Systematic search was performed for all studies on LO for palpable undescended testes, excluding small case series or duplicate results, and for all comparative studies between LO and OO in palpable undescended testes. Fisher's exact test was used to assess associations between success and complications rates and different LO approaches. Meta-analysis was employed to compare LO and OO.

Results: Success rates were not affected by regular high retroperitoneal dissection (p=1.0), Prentiss maneuver (p=1.0) or intrascrotal fixation (p=1.0). Moreover, higher complications rates were noticed with regular high dissection (p=0.002) and Prentiss maneuver (p=0.01). The meta-analysis did not show significant differences between LO and OO in success (p=0.17) and complications (p=0.14) rates, while the cost of LO was higher in all comparative studies.

Conclusions: Available evidence shows higher benefit-cost ratio for OO and, therefore, the latter should remain the procedure of choice. LO can be alternatively used, as it shows comparable safety and efficacy, but it should not include high dissection, Prentiss maneuver and testis fixation, when not necessary. Further study of final scrotal position, including control for the confounding role of initial testis position (high vs. low palpable testes), is required.

Keywords: laparoscopic orchiopexy; open inguinal orchiopexy; meta-analysis; minimally invasive pediatric surgery; palpable undescended testes; Prentiss maneuver; systematic review; testicular atrophy; testis fixation; transcrotal trocar

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1. INTRODUCTION

1.1 BACKGROUND

Testis nondescent is one of the most common abnormalities in children. Approximately 80% of undescended testes are palpable and 20% nonpalpable [EAU Guidelines on Pediatric Urology 2018]. Open inguinal orchiopexy is the universally accepted method for the management of palpable undescended testes [EAU Guidelines on Pediatric Urology 2018]. Diagnostic laparoscopy, followed by one or two-stage laparoscopic orchiopexy or inguinal exploration, is generally recommended for nonpalpable testes [EAU Guidelines on Pediatric Urology 2018].

Over the last decade, a few authors presented their results from laparoscopy in patients with palpable undescended testes [Elderwy AA *et al.* 2014, Escarcega-Fujigaki P *et al.* 2011, He D *et al.* 2008, Riquelme M *et al.* 2015, Yang Z *et al.* 2020, You J *et al.* 2020], with some of them claiming that laparoscopic orchiopexy is superior to open orchiopexy and could be recommended for these testes [Yang Z *et al.* 2020]. The main proposed benefits of laparoscopic orchiopexy include the feasibility of high retroperitoneal dissection and/or of rerouting the testis through a shorter pathway medial to the epigastric vessels (Prentiss maneuver) and a consequent more favorable scrotal position [Yang Z *et al.* 2020]. However, the results from comparative studies between laparoscopic and open inguinal orchiopexy in palpable undescended testes vary, with most findings indicating same efficacy and safety for the two methods and higher cost for laparoscopic orchiopexy [Elderwy AA *et al.* 2014, Escarcega-Fujigaki P *et al.* 2011, Yang Z *et al.* 2020]. Accordingly, whether laparoscopic orchiopexy represents the best quality care for patients with palpable undescended testes and the best value for money for the health system at the same time and, thereby, should be recommended as procedure of choice is debatable.

1.2 DESIGN AND GOALS OF THE STUDY

The present study includes: (i) a systematic review of the success and complications rates in relation to several different approaches used in laparoscopic orchiopexy of palpable undescended testes, such as high retroperitoneal dissection, Prentiss maneuver, epigastric vessels clipping, use of transcrotal trocar or grasper, and transcrotal testis fixation; (ii) a meta-analysis comparing the efficacy and safety, i.e., the success and complications rates, between laparoscopic orchiopexy and open inguinal orchiopexy in palpable undescended testes. The synthesis of all published studies achieved by employing the methodology of the systematic review and meta-analysis offers a more accurate and comprehensive assessment of the methods under study rather than each study separately. In other words, the combined results have higher statistical power than the results of each study alone for a definite conclusion to be drawn.

Aims of the present study are (i) the investigation of the effect, if any, of several different approaches used in laparoscopic management of palpable undescended testes on the outcomes (success and complications) and (ii) the comparison of the outcomes (success and complications) between laparoscopic and open management of palpable undescended testes. Ultimate goal of the study is to evaluate the safety and efficacy of laparoscopic management of palpable undescended testes, as well as of its various technical approaches, and to compare with the standard open orchiopexy.

1.3 CLINICAL RELEVANCE OF THE STUDY

The present study, using the methodology of the systematic review and meta-analysis, overcomes the difficulties of controversial literature results and heterogeneity and offers a combination of all published results leading to an overall assessment of the outcomes of the surgical techniques under study. As a consequence, our findings will offer important information and evidence about the overall outcomes of laparoscopic orchiopexy in palpable undescended testes, as well as about the differences, if any, of its outcomes from the classic inguinal orchiopexy. This evidence will assist towards an evidence-based decision making in the choice of the surgical technique by pediatric surgeons and urologists during management of palpable undescended testes.

2. MAIN PART

2.1 DEFINITIONS – ANALYSIS OF BASIC CONCEPTS

TESTIS NONDESCENT

Testis nondescent is one of the most common abnormalities in boys. Normal testis descent into the scrotum relies on numerous hormonal and mechanical factors and is expected to be completed by gestational week 35 [Hutson JM 2012]. On some occasions, as in prematurity, testis descent might be delayed, but it is then also expected to be completed by the first 6-12 months of postnatal life the latest [Lee J & Shortliffe LM 2014]. Accordingly, the incidence of congenital testis nondescent is reported to be as high as 3-4% at birth for full-term infants and as high as 30-70% for premature infants, but is down to 1% at 1 year [Hutson 2012, Lee J & Shortliffe LM 2014]. Added to this 1% of cases with congenital cryptorchidism, another 1-4% of boys are diagnosed with testis nondescent later in life (usually around the age of 5 years) [Lee J & Shortliffe LM 2014]. The latter cases are attributed to the relatively new variant of acquired cryptorchidism or, otherwise, secondary testicular ascent [Hutson 2012, Lee J & Shortliffe LM 2014]; in fact one third of these cases had reportedly been previously retractile testes, i.e., normally descended testes which often retract to higher positions due to increased cremaster muscle activity.

The association between testis nondescent and infertility, and testis nondescent and testis malignancy potential is well established. Germ cell loss starts at six months of age in congenital cryptorchidism [Hadziselimovic F & Herzog B 2001] and increases monthly for a testis remaining undescended [Tasian GE 2009], ultimately leading to subfertility. Fertility rates might be comparable to those in general population (90%) in unilateral cases managed promptly, but might drop to 50% in bilateral cases even with timely management [Hutson 2012, Lee J & Shortliffe LM 2014]. Also, secondarily ascended testes are known to share the same histopathologic abnormalities with congenitally undescended testes [Rusnack SL 2002]. The risk of testis tumour in men with a past history of testis nondescent is reported as 5- to 10-fold, with the risk being highest for intrabdominal testes and for testes managed late [Hutson 2012, Lee J & Shortliffe LM 2014].

The management of testis nondescent beyond 6 months of age is surgical. Hormonal treatment can play some role as neoadjuvant or adjuvant modality, particularly in cases with increased subfertility potential such as those with bilateral or intrabdominal undescended testes, but cannot replace surgery [EAU Guidelines on Pediatric Urology 2018]. The surgical procedure, known as orchiopexy, typically includes orchiolysis, i.e., mobilization of the vas deferens and testicular vessels, interruption of the communication between intravaginal cavity (cavity of patent processus vaginalis) and intraperitoneal cavity, and secure placement of the testis in the scrotal bag, usually in a subdartos pouch. Surgical treatment should be offered from the age of six months and should not be delayed later than 12-18 months [EAU Guidelines on Pediatric Urology 2018].

PALPABLE AND NONPALPABLE UNDESCENDED TESTES

Undescended testes might be located along the pathway of testis descent and, thus, be intrabdominal, intracanalicular (inside inguinal canal) or prescrotal (between external inguinal ring and scrotal entrance), or might be located outside the pathway of descent, i.e., be in ectopic positions [Hutson JM 2012]. Ectopic testes have exited the external inguinal ring and have deviated from the pathway of descent, lying in pouches between the superificial and deep (investing) fascia [Mirilas P & Mentessidou A 2013]; the most common ectopic position is the superficial inguinal pouch (also known as Dennis-Brown position) just above the external inguinal ring, while other rare ectopic positions include the penile, the femoral and the perineal pouches.

The most clinically useful classification of undescended testes is distinguishing into palpable and nonpalpable testes [EAU Guidelines on Pediatric Urology 2018]. Approximately 80-90% of undescended testes are palpable and less than 20% are nonpalpable. Testes that had exited the inguinal canal, i.e., prescrotal and ectopic, can be easily palpated. Intracanalicular testes can be usually palpated but sometimes might not be palpable, depending on the examiner's experience and the child's cooperativeness. High canalicular testes which are located right at the internal inguinal ring and are sometimes palpable and other times nonpalpable are also known as peeping testes. Nonpalpable testes include some canalicular testes, intrabdominal testes and cases of testicular absence. The latter might be due to perinatal testicular torsion and subsequent atrophy (vanishing testis) or due to agenesis of the testis.

The surgical management is decided based on the palpability and the estimated location of the testis (**Figure 1**) [EAU Guidelines on Pediatric Urology 2018]. Standard inguinal orchiopexy is generally recommended for a palpable testis and diagnostic laparoscopy for a nonpalpable testis remaining nonpalpable under general anesthesia [EAU Guidelines on Pediatric Urology 2018]. Diagnostic laparoscopy will help ruling out testis absence and, in testis presence, it might be followed by laparoscopic orchiopexy or open inguinal orchiopexy, depending on the exact position of the testis and the surgeon's preference.

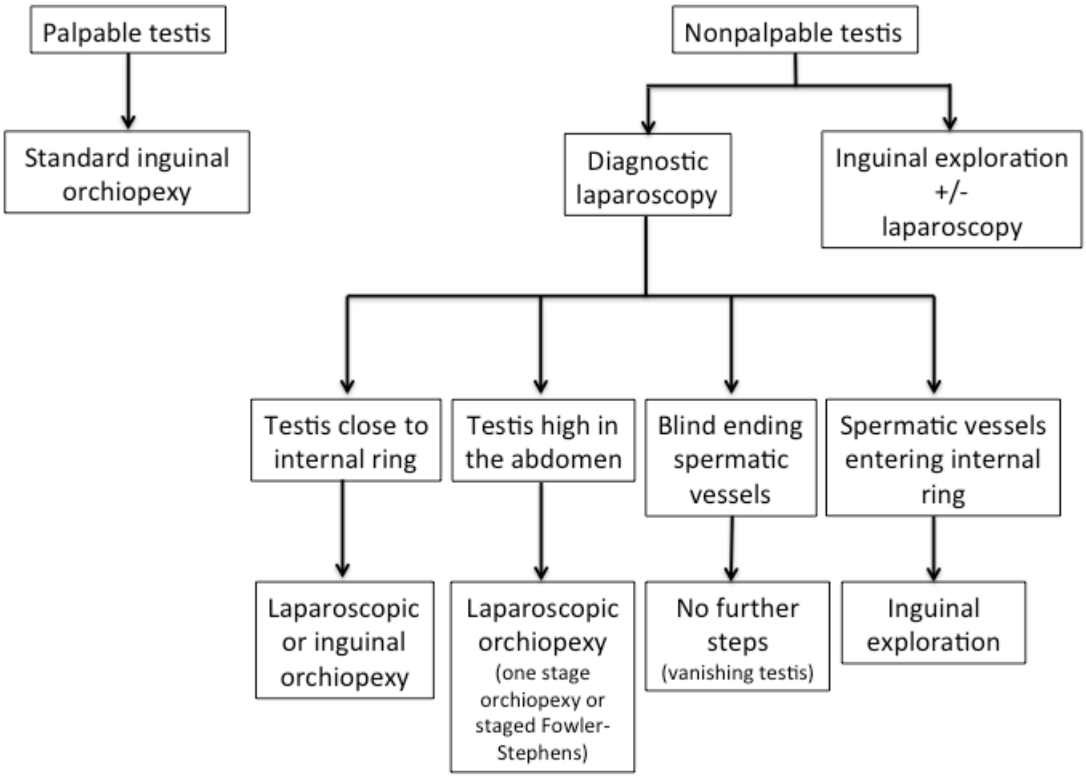


Figure 1. Flowchart for the management of palpable and nonpalpable undescended testes (Modified from European Society for Pediatric Urology (ESPU). EAU Guidelines on Pediatric Urology. European Association of Urology 2018; pp 13-8. Accessed at https://uroweb.org/wp-content/uploads/EAU-Guidelines-on-Paediatric-Urology-2018-large-text.pdf Sep 15, 2020)

OPEN APPROACH FOR PALPABLE UNDESCENDED TESTES

Standard transinguinal orchiopexy constitutes the classic approach recommended for the management of palpable undescended testes [EAU Guidelines on Pediatric Urology 2018]. It includes mobilization of the testis, division of gubernaculum, ligation of the processus vaginalis and mobilization of the spermatic cord to the level of the internal inguinal ring, and testis placement in a subdartos pouch in the scrotum [Hutson JM 2013]. This technique is widely applied for intracanalicular, prescrotal and ectopic testes, with success rates as high as 95% [Lee

J & Shortliffe LM 2014]. Even high canalicular testes, such as peeping testes, can be sucessfuly managed with this approach.

Low-positioned undescended testes, which can be manipulated into the scrotum, such as testes lying at the scrotal neck, can be alternatively managed with the transcrotal approach [EAU Guidelines on Pediatric Urology 2018; Lee J & Shortliffe LM 2014]. Transcrotal orchiopexy, first introduced by Bianchi and Squire [Bianchi A & Squire BR 1989], includes gubernaculum division, ligation of the processus vaginalis if found patent and spermatic cord mobilization up to the level of the canal, and secure placement of the testis in a subdartos scrotal pouch [Hinman F & Baskin LS 2009, Hutson JM 2013]. Success rates range from 88 to 100% [Novaes HF *et al*. 2013] and are overall reported as comparable to those of the inguinal approach [Feng S *et al.* 2016]. Some authors claim that transcrotal orchiopexy can be also feasible for high inguinal testes through retraction on the external inguinal ring and traction or even by opening of the inguinal canal [Callewaert PRH 2010]; European Society of Pediatric Urologists, however, supports that an additional inguinal incision will be compulsory to correct appropriately an associated inguinal hernia in up to 20% of cases approached transcrotally, and, recommends selective use of the transcrotal approach in low-positioned testes [EAU Guidelines on Pediatric Urology 2018].

LAPAROSCOPIC APPROACH FOR PALPABLE UNDESCENDED TESTES

Single-stage laparoscopic orchiopexy can be performed in palpable undescended testes, which, however, have not deviated from the normal pathway of descent and, thereby, can be retracted easily in the abdomen. Ectopic testes are not suitable for laparoscopic orchiopexy, as it is difficult to retract them and grasp their deviated gubernaculum [He *et al.* 2008]. The procedure was first introduced in 1995 in a small series of patients [Docimo SG *et al.* 1995] but did not gain wide acceptance. Recently, a few authors have shown interest and revisited the technique by presenting their results in larger series [Elderwy AA *et al.* 2014, Escarcega-Fujigaki P *et al.* 2011, He D *et al.* 2008, Riquelme M *et al.* 2015, Yang Z *et al.* 2020, You J *et al.* 2020]. Reported success rates are as high as 98%-100%.

The surgical field in the laparoscopic approach to the inguinal testes is shown in **Figure 2A**. The testis has exited the abdomen and therefore cannot be seen, but the vas deferens and internal spermatic vessels can be seen coursing in the pelvis to enter the internal inguinal ring. The procedure starts with an incision of the peritoneum lateral to the internal spermatic vessels continued down around the internal inguinal ring [Elderwy AA *et al.* 2014] (**Figure 2A**, long dashed line). Transection of the peritoneum around the internal ring leads to interruption of the communication of the processus vaginalis with the intraperitoneal cavity and obviates the need for formal hernia repair [Yang Z *et al.* 2020]. The testis is then retracted in the abdomen and the gubernaculum is divided distally. Gubernacular division is followed by a second incision on the peritoneum medial to the vas deferens [Elderwy AA *et al.* 2014] (**Figure 2A**, short dashed line). The vas and vessels are mobilized by releasing them from the peritoneum and retroperitoneum (**Figure 2B**). If the testis can reach the contralateral ring, length for orchiopexy is sufficient. High retroperitoneal dissection of the spermatic vessels up to the lower renal pole can be performed if necessary. Also, Prentiss maneuver, which involves rerouting of the testis into the scrotum through a short neocanal medial to the epigastric vessels, can be used if needed.

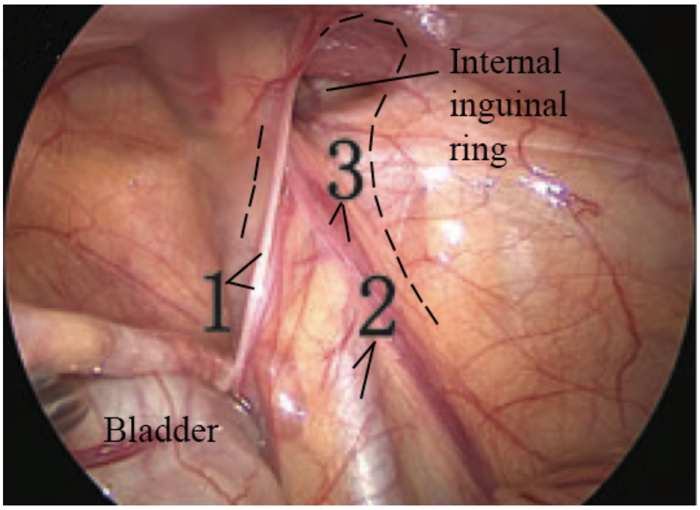


Figure 2A. Intraoperative photograph showing the surgical field in laparoscopy for an inguinal testis. Upon inspection of the intraperitoneal cavity, the vas deferens (1) can be seen coursing from behind the bladder laterally towards the internal inguinal ring. The internal spermatic vessels (3) run from the retroperitoneum towards the internal ring. The ring appears open, indicating a patent processus vaginalis. 2: iliac vessel. The long dashed line shows the planned incision on the peritoneum lateral to the spermatic vessels and around the internal ring, and the short dashed line shows the planned incision medial to the vas deferens. (Modified from Yang Z *et al*. Laparoscopic orchiopexy versus open orchiopexy for palpable undescended testis in children. J Laparoendosc Adv Surg Tech A 2020; 30: 453-7)

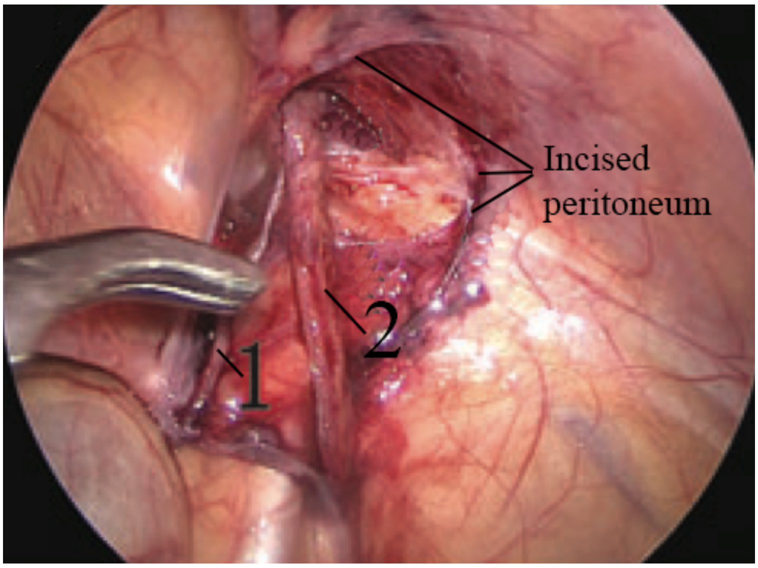


Figure 2A. Intraoperative photograph during laparoscopic orchiopexy for an inguinal testis. The peritoneum around the internal inguinal ring and on top of the spermatic vessels and vas deferens has been dissected off. (Modified from Yang Z *et al*. Laparoscopic orchiopexy versus open orchiopexy for palpable undescended testis in children. J Laparoendosc Adv Surg Tech A 2020; 30: 453-7)

To bring the testis down, a grasper is introduced through the internal ring (or through an incision performed medial to the epigastric vessels) from above into the scrotum. A second grasper is then led back from a scrotal incision through the inguinal canal (or the neocanal) into the abdomen, using the first grasper as a guide. The gubernaculum is grasped by the second grasper and the testis is brought down and placed in a subdartos pouch similarly to the standard inguinal orchiopexy. Alternatively, a transcrotal trocar can be used to facilitate testis delivery. It is suggested that the neocanal opened with the Prentiss maneuver should go through the outer ring or delivery of the testis is more difficult [He *et al.* 2008].

OPEN APPROACH FOR NONPALPABLE UNDESCENDED TESTES

The options included in the open approach to the nonpalpable testis are shown in **Figure 3**. Overall success rates of open orchiopexy techniques for nonpalpable testes range between 73% and 89% [Baker *et al.* 2001, Docimo *et al*. 1995, Yu C *et al*. 2018]. An undescended testis located close to the internal inguinal ring, which might be peeping and therefore not consistently palpable, can be successfully managed with the standard transinguinal approach [EAU Guidelines on Pediatric Urology 2018]. Traction on the patent processus vaginalis will aid sliding of the testis from inside the abdomen into the intravaginal cavity, where the surgeon can grasp it and proceed with the procedure as usual. Of course, retroperitoneal dissection might be necessary in such cases, in order to obtain sufficient length for the spermatic cord. Access to the surgical plane of the vas deferens and spermatic vessels starts by opening the internal inguinal ring. A key maneuver for successful orchiolysis is the incision of the secondary internal inguinal ring (opening of the membranous layer of extraperitoneal fascia just deep to the internal inguinal ring), which the vas and vessels enter with an acute angulation of their course, and subsequent liberation of the vas and vessels from the attachments of the membranous extraperitoneal fascia along their course in the retroperitoneum [Mirilas P *et al.* 2008].

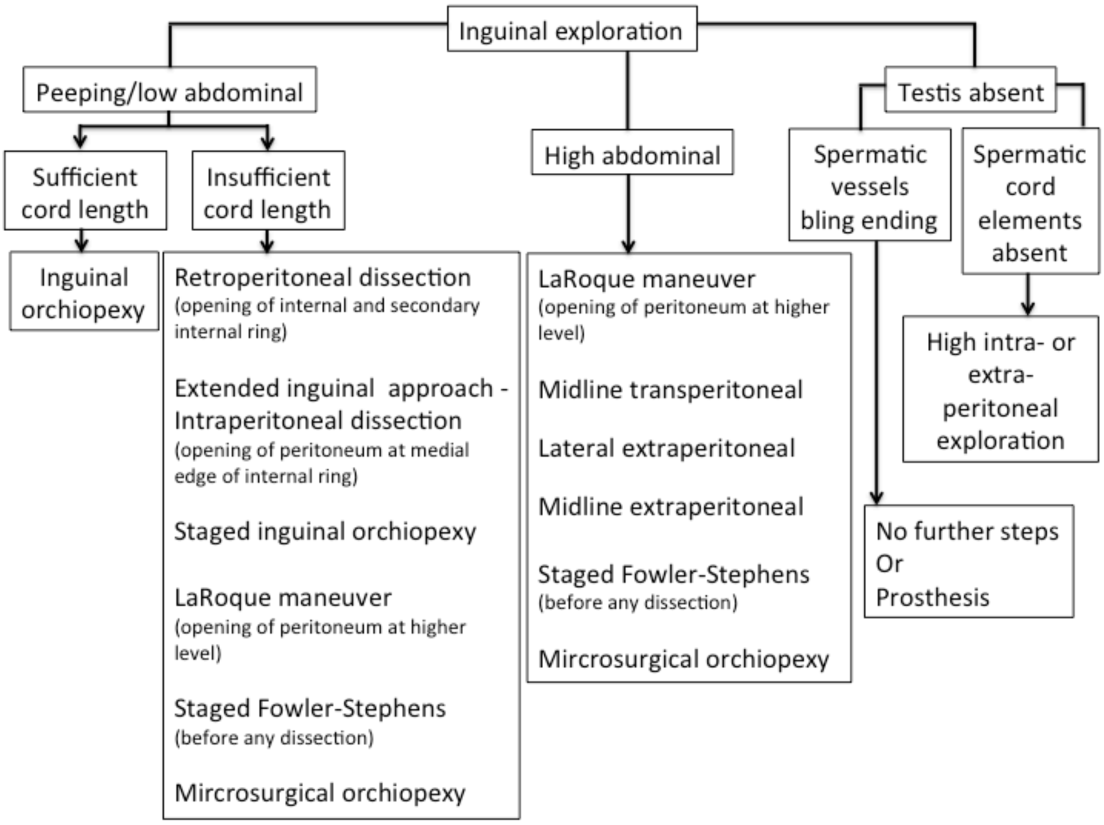


Figure 3. Flowchart for the open approach to nonpalpable testes (Based on Hinman F Jr & Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009).

Another option, particularly useful for when the testis cannot be brought down in the intravaginal cavity by pulling on the processus vaginalis, is the extended inguinal approach [Hinman F & Baskin LS 2009]. This approach includes opening of the peritoneum at the level of the internal inguinal ring. The external oblique muscle is opened, the internal oblique muscle retracted and the peritoneum should be opened widely at the medial edge of the internal ring to help tracing down the testis; a fine traction suture in the tunica albuginea at the lower testis pole can be subsuequently used to facilitate orchiolysis in the intraperitoneal cavity and orchiopexy.

Lastly, some authors using the transinguinal approach prefer to first mobilize the testis with its cord structures as low as possible and proceed with further mobilization into the scrotum in a second stage [Lee J & Shortliffe LM 2014]. The testis is usually fixed at the pubic tubercle in the first stage, while a Silastic sheet can be used to cover the spermatic cord, in order to avoid injuries to the vascular supply or the vas deferens due to the scarring in the second stage [Ferro *et al.* 1990]. A second stage, in which the testis is brought down into the scrotum follows 6-12 months later [Lee J & Shortliffe LM 2014].

Occasionally, a high intrabdominal testis cannot be approached transinguinally. The open techniques available for the management of these cases include LaRoque maneuver, the midline transperitoneal approach and the lateral or midline extraperitoneal approach [Hinman F & Baskin LS 2009] (**Figure 3**). In LaRoque approach, the inguinal skin incision is lengthened, the anterior wall of the inguinal canal is closed if previously opened, and a new incision in the external oblique fascia is created 3 cm superiorly for access directly into the peritoneum at a higher level. Identification of the testis and mobilization of the vas and vessels in the intraperitoneal cavity follow. High intrabdominal testes, particularly bilateral cases and/or older children, are best managed with the midline transperitoneal approach [Hinman F & Baskin LS 2009] (**Figure 4A**). With this approach, higher mobilization is possible (**Figure 4B**). Lastly, extraperitoneal approach can be achieved through a lower quadrant incision (or bilateral lower quadrant incisions for bilateral cases) or through a midline sufraumbilical incision (**Figure 5A**). What differs in the extraperitoneal approach, as compared to the intraperitoneal approach, is that the peritoneum is pushed medially and the testis might be initially concealed as it is located intraperitoneally [Hinman F & Baskin LS 2009]; it can be found attached within the posterior surface of the peritoneum by following the course of the vas deferens. Again, high mobilization is possible (**Figure 5B**).

Other options for high testes with a short vascular pedicle include Fowler-Stephens procedure and microsurgical orchiopexy. The latter includes anastomosis of the internal spermatic vessels with the epigastric vessels and is associated with a success rate of up to 90% [EAU Guidelines on Pediatric Urology 2018], but it demands microsurgical equipment and expertise.

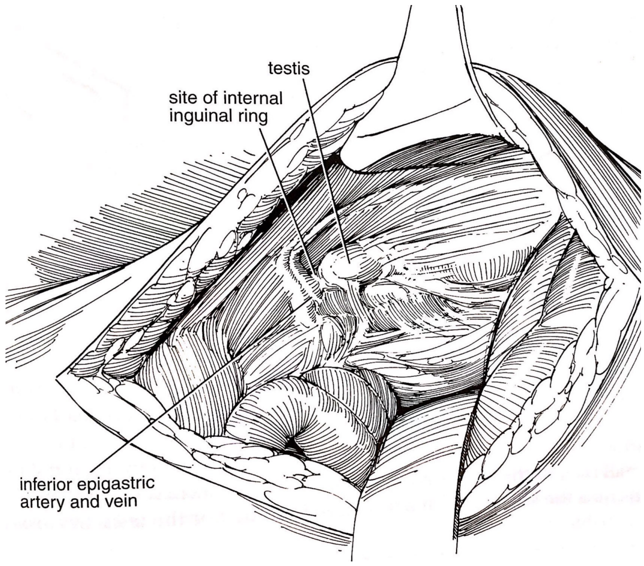


Figure 4A. Drawing of the surgical field in the midline (infraumbilical) transperitoneal approach. The intestines are packed aside (towards the midline), and the testis is usually found lying intraperitoneally, inside the internal ring or behind the bladder. (From Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

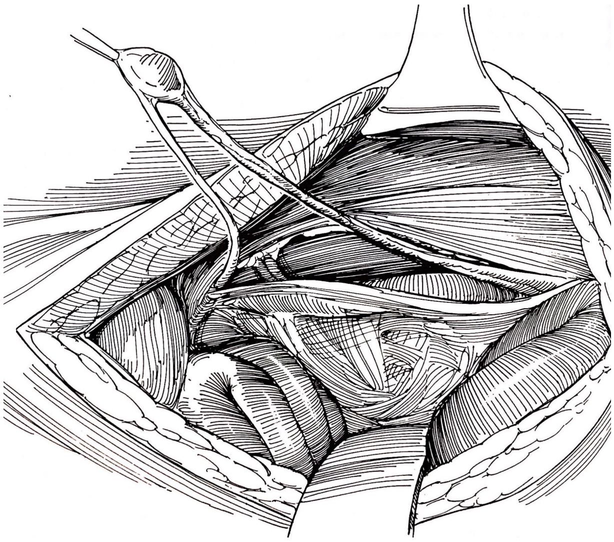


Figure 4B. Drawing showing the vas and vessels mobilization in the midline transperitoneal approach. The vas deferens is freed behind the bladder leaving 1 cm of peritoneum on either side (not shown in figure) and the vessels are freed in the retroperitoneum until the lower renal pole, to gain sufficient length for orchiopexy. (From Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

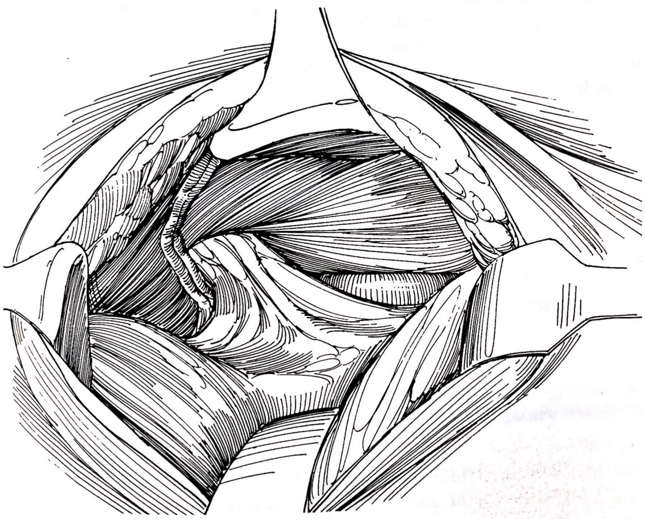


Figure 5A. Drawing of the surgical field in the extraperitoneal approach. The peritoneum is pushed medially. The vas deferens is first located behind the bladder and its course is followed to trace down the testis, which is usually intraperitoneally and therefore concealed in this approach. (From Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

Figure 5B. Drawing showing the vas and vessels mobilization in the extraperitoneal approach. The vas deferens and spermatic vessels are freed along their course to gain sufficient length for orchiopexy. (From Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

The Fowler-Stephens procedure includes high transection of the internal spermatic vessels as a first stage and orchiopexy with preservation of the lower collateral blood supply as a second stage 6-12 months later. Therefore, Fowler-Stephens procedure should be decided upon initial inspection [Hinman F & Baskin LS 2009]; it is not indicated for cases where extensive dissection of the spermatic cord has already taken place through the transinguinal or other approach and, thereby, the lower collateral blood supply has been disrupted. It is generally claimed that testes lying > 2 cm above the internal ring may not reach the scrotum without division of the spermatic vessels [EAU Guidelines on Pediatric Urology 2018, Kirsch AJ *et al.* 1998]. Although nowadays usually performed laparoscopically, the first stage can be performed through a short abdominal incision which allows indentification and high ligation of the internal spermatic vessels [Hinman F & Baskin LS 2009] or through the abdominal or high inguinal incision already used. One-stage Fowler-Stephens orchiopexy with high or low (just above the level of the testis) transection of the internal spermatic vessels, leaving intact all the lower collateral blood supply, and orchiopexy at the same time is no longer preferred, due to reported increased rates of testicular atrophy and consequent failure rates up to 33% (vs. 27% with two-stage Fowler-Stephens orchiopexy) [Baker *et al.* 2001, Hinman F & Baskin LS 2009].

A key maneuver that can be combined with most of the above approaches, in case the length of the vessels and/or vas is short, is the Prentiss maneuver. The latter includes creation of a new opening medial to the inferior epigastric vessels, in order to scrotalize the testis through a shorter path than the inguinal canal [Lee J & Shortliffe LM 2014]. Finally, scrotal fixation of the testis may be also important, particularly when testis intrascrotal placement is not entirely tension-free [Hinman F & Baskin LS 2009]. Non-absorbable sutures are preferred.

LAPAROSCOPIC APPROACH FOR NONPALPABLE UNDESCENDED TESTES

Laparoscopic approach is generally recommended for the management of nonpalpable undescended testes [EAU Guidelines on Pediatric Urology 2018] (**Figure 1**). The options for laparoscopic management of intrabdominal testes include one-stage orchiopexy or two-stage Fowler-Stephens orchiopexy [Hinman F & Baskin LS 2009]. Overall success rates of laparoscopic orchiopexy techniques for nonpalpable testes range between 88% and 93% [Baker *et al.* 2001, Yu C *et al*. 2018]. One-stage Fowler-Stephens orchiopexy can also be performed, but is usually not preferred due to reported higher rates of testicular atrophy and failure rates up to 26% (vs. 12% with two-stage Fowler-Stephens orchiopexy) [Baker *et al.* 2001].

The surgical field in the laparoscopic approach to the intrabdominal testes is shown in **Figure 6A**. Single-stage orchiopexy can be performed when the testis can be pulled over to reach the contralateral internal ring [Hinman F & Baskin LS 2009]. When this maneuver cannot be performed with ease and the testis is located > 2 cm above internal ring, it is suggested that division of the spermatic vessels is preferrable, i.e., two-stage Fowler-Stephens orchiopexy is recommended [EAU Guidelines on Pediatric Urology 2018].

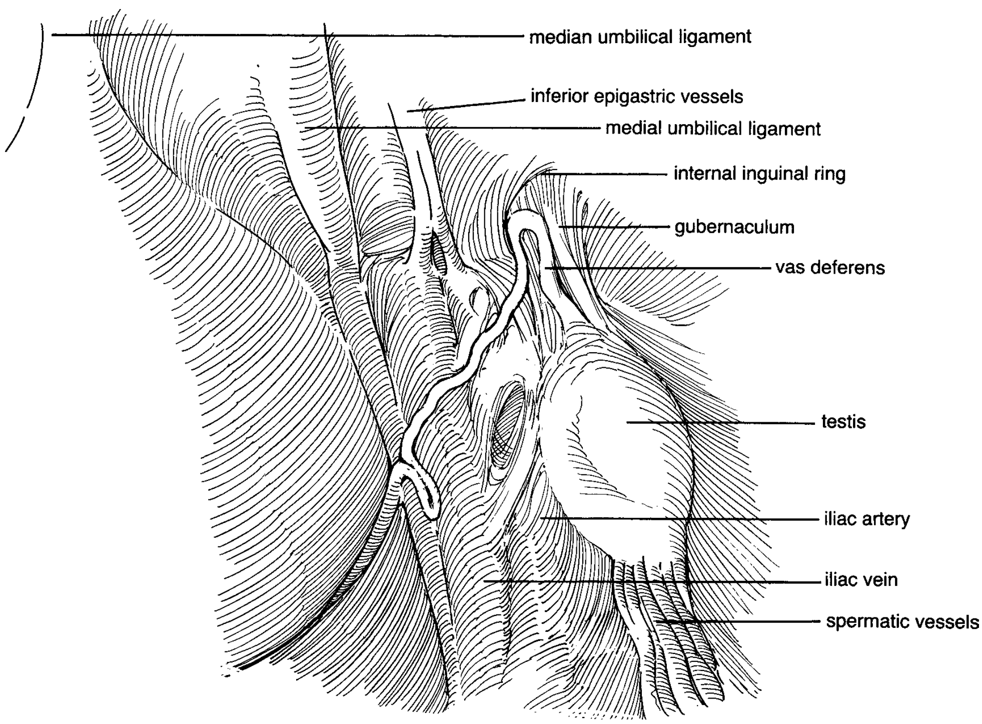


Figure 6A. Drawing of the surgical field in laparoscopy for an intrabdominal testis. Upon inspection of the intraperitoneal cavity, the median umbilical ligament (urachal remnant) runs from the bladder dome to the umbilicus. The vas deferens arises from behind the bladder and crosses the medial umbilical ligament (obliterated umbilical artery), while coursing towards the internal ring. The internal spermatic vessels run from the retroperitoneum towards the upper testis pole. The gubernaculum courses from the lower testis pole towards the internal ring. In case of testis absence (vanishing testis), the spermatic vessels and vas deferens might either end blindly in the abdomen, or enter the internal ring and end blindly in the canal; the testicular remnant (if any) in the latter case will not be obvious on laparoscopy and will most likely require inguinal exploration. (From Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

Single-stage orchiopexy includes incision of the peritoneum around the internal ring and lateral to the testis and spermatic vessels (**Figure 6B**), mobilization of the spermatic vessels and vas deferens leaving a broad isthmus of peritoneum on them (**Figure 6C**), release of the gubernaculum from within the internal ring by dividing it as distally as possible, and orchiopexy in a subdartos scrotal pouch through a neocanal (Prentiss maneuver) or the inguinal canal itself. The testis can be brought down using a transcrotal trocar or a grasper. During mobilization of the vas and spermatic vessels, the testis is periodically moved towards the contralateral internal inguinal ring to estimate whether sufficient length has been attained to move it into the scrotum [Abolyosr A 2006]; when additional vessels and vas length is needed, the peritoneum medially to the vessels and the peritoneum medially to the vas down to the bladder can be also incised to allow more extensive mobilization.

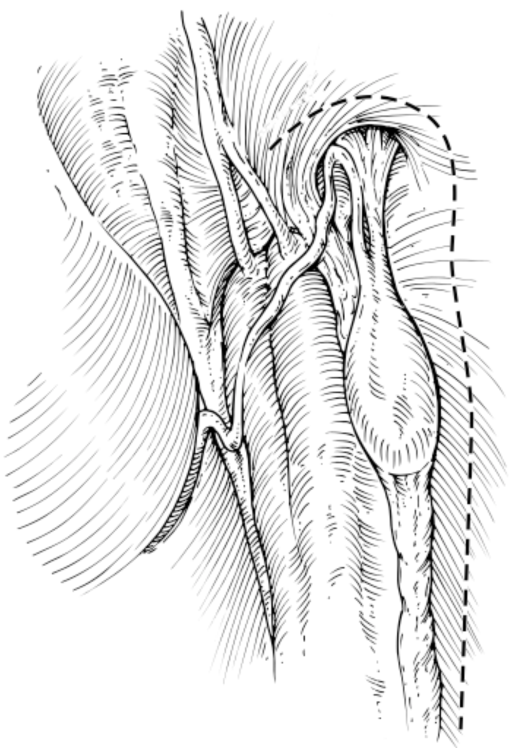


Figure 6B. Drawing showing the incision of peritoneum during laparoscopic orchiopexy for an intrabdominal testis. The peritoneum is incised starting around the internal ring distally, the incision is continued proximally to border the testis and the spermatic vessels laterally up to the lower pole of the kidney (long dashed line). This incision is located 1 cm away from the vas deferens and the spermatic vessels, in order to leave a flap of peritoneum on them, which will encompass the vas deferens and testis blood supply. (Modified from Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

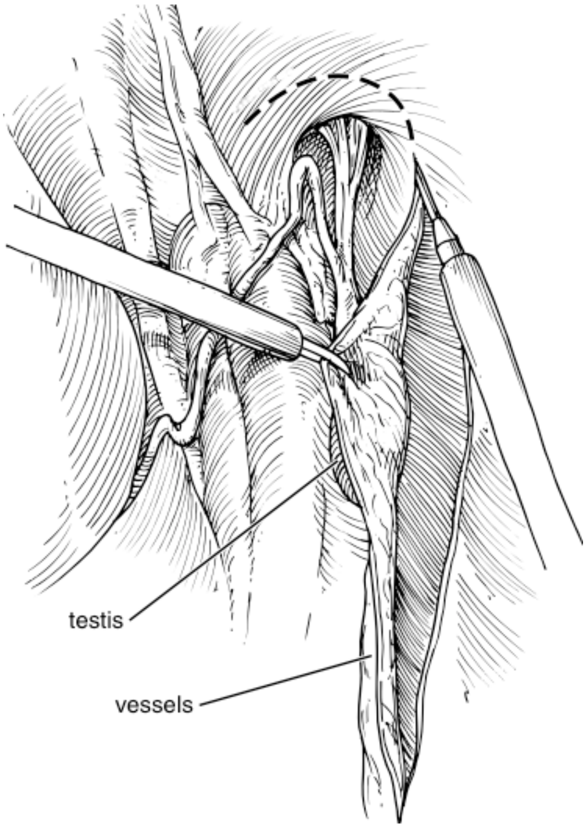


Figure 6C. Drawing showing the laparoscopic mobilization of an intrabdominal testis. Mobilization of testis will follow, by deepening the aforementioned incision and release of the vessels and vas along with their peritoneal covering. Care is taken to avoid injury to the ureter, which lies underneath crossing the iliac vessels. More extensive mobilization will require incision of the peritoneum medial to the vas down to the bladder and incision of the peritoneum medial to the spermatic vessels (not shown in figure). (Modified from Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

Two stage Fowler-Stephens procedure includes a first stage, in which the internal spermatic vessels are ligated as high as possible. Unipolar or bipolar diathermy or clipping can be used [Hinman F & Baskin LS 2009]. The second stage, typically performed 6 months later, includes orchiolysis leaving a generous triangular flap of peritoneum around the testis and vas deferens to preserve the lower collateral blood supply derived from the vas deferens (**Figure 7A**), distal release of the gubernaculum (**Figure 7B**), and orchiopexy usually using Prentiss maneuver.

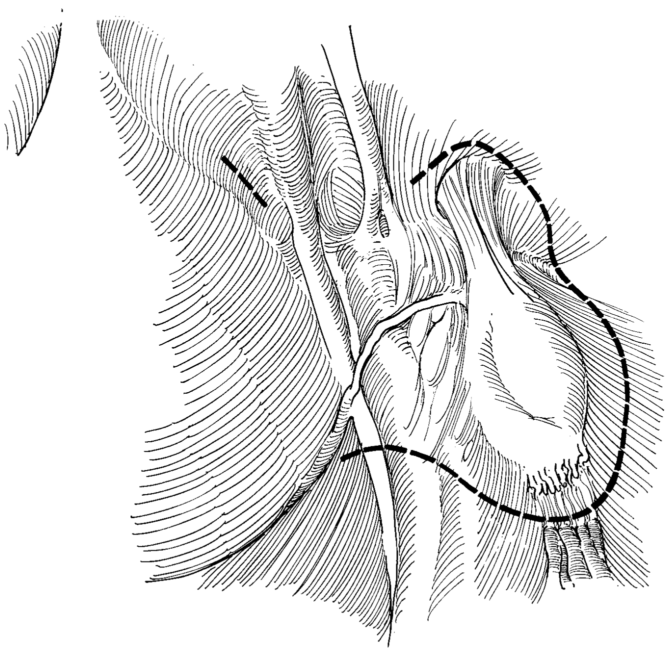


Figure 7A. Drawing showing the incision of peritoneum during laparoscopic 1st stage Fowler-Stephens orchiopexy for an intrabdominal testis. The peritoneum is incised starting around the internal ring distally, the incision is continued proximally bordering the testis laterally and, above the testis, is turned medially at the site of the previous spermatic vessels ligation (long dashed line). This incision is located at least 1 cm away from the vas deferens, in order to leave a large triangular flap of peritoneum on it, which will encompass all the lower collateral supply to the testis derived from the vas deferens. The short dashed line shows an incision on the anterior wall peritoneum between the bladder and the medial umbilical ligament to bring the testis down through a short neocanal; others prefer to perform this incision between the medial umbilical ligament and the epigastric vessels, to avoid injury to the bladder. (From Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

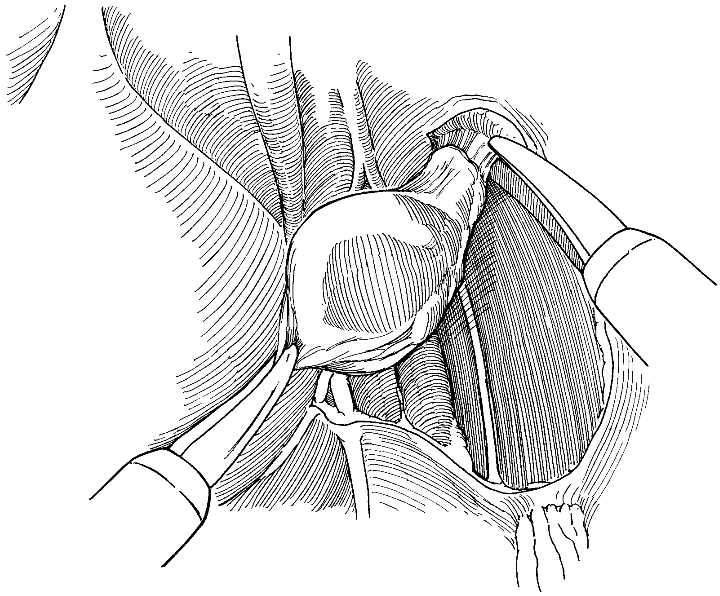


Figure 7B. Drawing showing the mobilization of an intrabdominal testis during laparoscopic 2nd stage Fowler-Stephens orchiopexy. Mobilization will follow similarly to the single-stage orchiopexy. The gubernaculum is divided as distally as possible. (From Hinman F Jr, Baskin LS. Hinman's Atlas of Pediatric Urologic Surgery. 2nd ed. Philadelphia: Saunders-Elsevier 2009)

2.2 METHODOLOGY

STUDY DESIGN

The present study is a systematic review of all published studies on laparoscopic orchiopexy of palpable undescended testes in MEDLINE and EMBASE databases. The afore-mentioned databases were searched using the keywords 'laparoscopic orchiopexy', 'palpable undescended testes' and 'children'. The reference lists of relevant publications were also searched. No further contact with the authors was made.

Exclusion criteria for the systematic review were non english-language articles, preliminary studies whose results were duplicated in later final studies and reports in the early learning period with fewer than 10 cases. The latter were excluded to minimize bias related with an early learning curve. Exclusion criteria for the meta-analysis were studies not reporting results on inguinal orchiopexy (i.e., studies focused on laparoscopic orchiopexy).

Our study conformed to the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-analyses) [Moher *et al.* 2010], including clearly reported identification, screening for eligibility and selection of articles which are under the focus of the study, critical analysis of the data included, appropriate statistical analysis for systematic review and meta-analysis, and presentation of results in a systematic way.

PARAMETERS UNDER STUDY

For each study, the following parameters were recorded for laparoscopic orchiopexy only (in studies focusing on laparoscopic orchiopexy) or for laparoscopic orchiopexy and open orchiopexy separately (in comparative studies): number and age of patients, number of testes, operative time (min), follow up duration (years), cost, as well as rates of success, defined as an appropriate scrotal position with no signs of testicular atrophy, of low scrotal position (where reported), and of recurrence, testicular atrophy and overall complications, defined as the total intraoperative and postoperative complications.

STATISTICAL ANALYSIS

Fisher's exact test was used to assess associations between success and complications rates and different laparoscopic orchiopexy approaches (high retroperitoneal dissection, Prentiss maneuver, epigastric vessels clipping, use of transcrotal trocar, testis fixation). SPSS V. 25 software was used for these statistics.

Meta-analysis for binary variables (presence of success, low scrotal position and complications) was performed using as a measure of effect the odds ratio (OR), which represents the increased (or decreased) odds of an event of interest associated with exposure to the factor of interest [Petrie A & Sabin C 2000]. An OR of 1 indicates that the estimated effects are the same in the exposed (laparoscopic orchiopexy) and unexposed (open orchiopexy) groups. An OR>1 shows increased odds of an event in the exposed group compared with the unexposed group, and an OR<1 indicates reduced chances of an event in the exposed group. Meta-analysis for continuous variables (operative time) was performed using the standardized difference in means (SMD) [Petrie A & Sabin C 2000]. The SMD was calculated using the mean, standard deviation and the sample size given in each comparative study. A zero SMD implies no effect of the factor of interest. There was no heterogeneity among studies in all tested variables (I^2=0%), and, therefore, the fixed effect model of meta-analysis was used [Guo J *et al.* 2011]. Comprehensive Meta-Analysis (CMA) V.3 software was used for the meta-analysis.

2.3 RESULTS

One hundred twenty-two studies were initially retrieved. Screening of all these studies (abstract or full text when necessary) led to exclusion of 116 studies, leaving six studies [Elderwy AA *et al.* 2014, Escarcega-Fujigaki P *et al.* 2011, He D *et al.* 2008, Riquelme M *et al.* 2015, Yang Z *et al.* 2020, You J *et al.* 2020] eligible for inclusion in the systematic review (**Figure 8**). Of these, three studies were focused on LO [He D *et al.* 2008, Riquelme M *et al.* 2015, You J *et al.* 2020], and three studies were comparative between LO and OO [Elderwy AA *et al.* 2014, Escarcega-Fujigaki P *et al.* 2011, Yang *et al.* 2020] and thus eligible for inclusion in the meta-analysis (**Figure 8**).

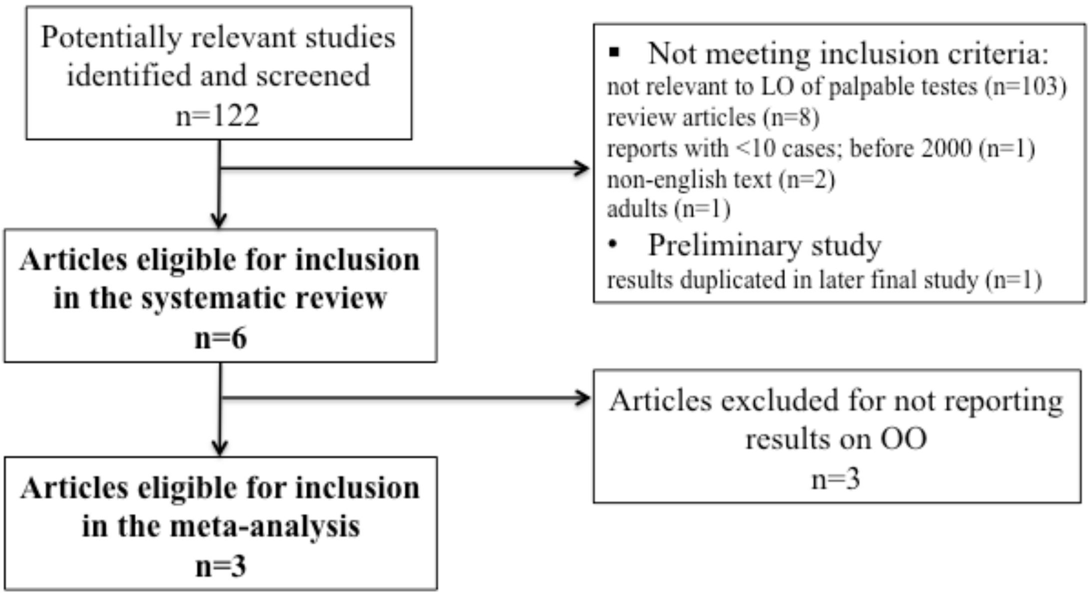


Figure 8. Flowchart showing the identification, screening for eligibility and inclusion of articles in the systematic review and in the meta-analysis.

SYSTEMATIC REVIEW OF LAPAROSCOPIC ORCHIOPEXY IN PALPABLE UNDESCENDED TESTES

A total of 1193 patients who underwent laparoscopic orchiopexy for 1363 palpable undescended testes were included. Age of the included patients, operative time and postoperative follow up duration in each study can be seen in **Table 1**. Low-positioned testes were excluded in three studies: ectopic and retractile testes in two studies (n=972 included testes) and testes at the scrotal neck in one study (n=140 included testes); high inguinal, i.e., peeping, testes were excluded in one study (n=192 included testes); one study did not specify any exclusion criteria (n=38 included testes); lastly, one study included only peeping testes (n=21), the majority of which were palpable and those which could not be palpated were documented inside the inguinal canal on ultrasound.

Studies	Design	No. patients	Patients' age (yr)	No. testes	Operative time (min)	Follow up duration (yr)
He 2008[a]	Retrospective	90	1.4 (0.7-6)	103	First 15 cases: 85.7±44.1 Next 31 cases: 32.7±5.2	0.5-1
Escarcega-Fujigaki 2011[b]	Prospective	30		38	45	
Elderwy 2014[b]	RCT	21	2.0 (1.5, 4)	21	40 (40, 45)	2 (2, 3)
Riquelme 2015[a]	Retrospective	155	0.8-3	192	47	0.5-15
You 2020[a]	Retrospective	773	1.6 (0.5-8)	869	34.8±5.4	0.5-1.5
Yang 2020[a]	Prospective	124	2.3 (0.7-11)	140	62.5±15.2	1 (0.9-1.1)

Table 1. Design, sample size, demographic characteristics, operative time and follow up duration in each study included in the systematic review

[a]Data are presented as mean and range (x-y) or mean ± standard deviation; [b]Data are presented with median only or median and interquartile range (x, y)

Regular high retroperitoneal dissection was reported in two studies (n=161; 11.8%), of which one included only peeping testes and the other had excluded testes at the scrotal neck. Two studies reported high retroperitoneal dissection only when necessary (n=972; 71.3%); both these studies had excluded ectopic and retractile testes, and one of these specified that high retroperitoneal dissection was necessary in about 37.9% of the cases. The rest two studies did not specify whether high dissection in the retroperitoneum took place (n=230; 16.9%).

The Prentiss maneuver was used systematically in two studies (n=124 testes; 9.1%) and only when considered necessary for the presence of high testicular position, short cord and/or tension in two studies (n=332; 24.4%). In the rest two studies (n=907; 66.5%), the testis was brought down through the inguinal canal, i.e., laterally to the inferior epigastric vessels. A 5-10 mm transcrotal trocar was used to bring the testis down in three studies (n=333 testes; 24.4%), a transcrotal grasper in two studies (n=161; 11.8%) and a home-made device in one study (n=869; 63.8%). Prentiss maneuver was regularly combined with a transcrotal trocar in one study (n=103) and with a transcrotal grasper in another study (n=21). Passage through the inguinal canal was regularly combined with a transcrotal trocar in one study (n=38) and with a home-made device in another study (n=869). Of the two studies which employed both Prentiss maneuver and passage through the canal, one reports regular use of a 10 mm transcrotal trocar after clipping the epigastric vessels in order to be able to move the vessels laterally during passage of the trocar medially (n=192) and the other reports usage of a transcrotal grasper (n=140).

The testis was fixed in the scrotum systematically in four studies (n=1120 testes; 82.2%), was not fixed in one study (n=140; 10.3%), while whether the testis was fixed or not was not specified in one study (n=103; 7.5%). Of the studies in which orchiopexy included testis fixation, only one specified the material used (polypropylene 5/0). Regular testis fixation is reported in the two studies in which Prentiss maneuver was not used, while of the two studies in which Prentiss maneuver was employed, one reports regular testis fixation and the other does not specify.

Overall success rate was 99.7% (range, 98.9%-100%). There were four failures in total, due to conversion to open orchiopexy for the testis was ectopic (n=1), due to testis reassent (n=2) and due to atrophy (n=1). Only two testes (0.15%) required redo orchiopexy; the rest 1361 testes were found in an appropriate scrotal position (including the one which atrophied). In two of the studies, which documented the exact position of the testis during postoperative follow up visits [Elderwy AA *et al.* 2014, Yang *et al.* 2020], 144 out of 161 testes (89.4%) were in a low scrotal position, and the rest 17 testes (10.6%) were in mid or higher scrotum; all these positions were evaluated as appropriate scrotal positions, which did not necessitate redo orchiopexy.

No significant differences could be determined in success rates between orchiopexies including regular high retroperitoneal dissection (100%, n=161) and those including high retroperitoneal dissection only when necessary (100%, n=972), or between orchiopexies with regular use of Prentiss maneuver (100%, n=124) and those with regular passage of the testis through the inguinal canal (100%, n=907). Similarly, testis fixation did not prove to be related with the successful outcomes, as success rates were comparable between cases regularly fixed (99.6%, n=1120) and those that were not fixed (100%, n=140) (Fisher's test, p=1.0). In fact, the two recurrences noticed were reportedly fixed in the scrotum with polypropylene 5/0.

Overall complications rate was 0.7% (range, 0%-4.8%). Complications included intraoperative bleeding from epigastric vessels injury during insertion of the transcrotal trocar (n=2), testicular atrophy (n=1), testis reassent (n=2), scrotal hematoma (n=2) and wound infection (n=2).

Significantly higher complications rates were noticed with high retroperitoneal dissection [regular high dissection: 2.5% (n=161) vs. selective high dissection: 0.1%

(n=972); Fisher's test, *p*=0.002], as well as with Prentiss maneuver [medial neocanal: 1.6% (n=124) vs. inguinal canal: 0% (n=907); Fisher's test, p=0.01]. Complications associated with extensive retroperitoneal dissection included scrotal hematomas and wound infection, while complications associated with Prentiss maneuver included hemorrhage from the epigastric vessels and wound infection. On the other hand, no significant differences in complications were elicited when Prentiss maneuver was performed using a transcrotal trocar (1.0%, n=103) or a grasper (4.8%, n=21) (Fisher's test, *p*=0.30), or when the epigastric vessels were clipped prior to the trocar insertion (2.1%, n=192) or not (0.8%, n=133) (Fisher's test, *p*=0.65).

COMPARISON BETWEEN LAPAROSCOPIC AND OPEN ORCHIOPEXY IN PALPABLE UNDESCENDED TESTES (META-ANALYSIS)

A total of 415 orchiopexies, 199 laparoscopic and 216 open, were included (**Table 2**). Sample size and age of the patients were comparable between laparoscopic and open orchiopexy groups in the studies included. Similarly, follow up duration exceeded the minimum of six months and was similar between the two techniques groups in all these studies.

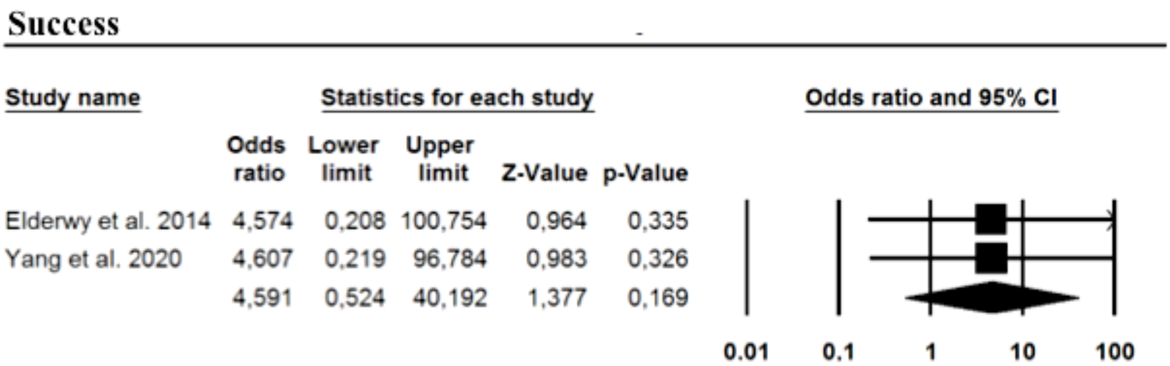
Table 2. Sample size, demographics and follow up duration for laparoscopic orchiopexy (LO) and open orchiopexy (OO) in each comparative study included in the meta-analysis

	No. pts		**Patients' age (yr)**		**No. testes**		**Follow up duration (yr)**	
Studies	LO	OO	LO	OO	LO	OO	LO	OO
Escarcega-Fujigaki 2011[a]	39	33	2.3 (1-10)		38	37	18	
Elderwy 2014[a]	21	25	2.0 (1.5, 4)	2.5 (1.5, 4)	21	25	2 (2, 3)	2 (1.5, 2)
Yang 2020[b]	124	132	2.3 (0.7-11)	2.5 (0.8-10)	140	154	1 (0.9-1.1)	1 (0.9-1.2)

[a]Data are presented as median and range (x-y) or as median and interquartile range (x, y); [b]Data are presented as mean and range (x-y)

Meta-analysis showed that the success rate, i.e., the rate of an appropriate scrotal position without atrophy, did not differ between laparoscopic and open orchiopexy (*p*=0.17) (**Figure 9**). However, the rate of a successful outcome associated with a low scrotal position proved overall higher with laparoscopic orchiopexy (OR=2.12, *p*=0.02), with this pooled result being nevertheless mainly determined by a single study [Yang *et al.* 2020]. As for complications, laparoscopic and open orchiopexy did now show significant differences in rates of testis reassent (*p*=0.17), atrophy, and overall complications (*p*=0.14) (**Figure 10**).

Studies	Success n/N (%)		Low scrotal position n/N (%)	
	LO	OO	LO	OO
Escarcega-Fujigaki 2011	38/38	37/37	Not reported	Not reported
Elderwy 2014	21/21	23/25	19/21	20/23
Yang 2020	140/140	152/154	125/140	120/152
Total	199/199 (100%)	212/216 (98.1%)	144/161 (89.4%)	140/175 (80%)



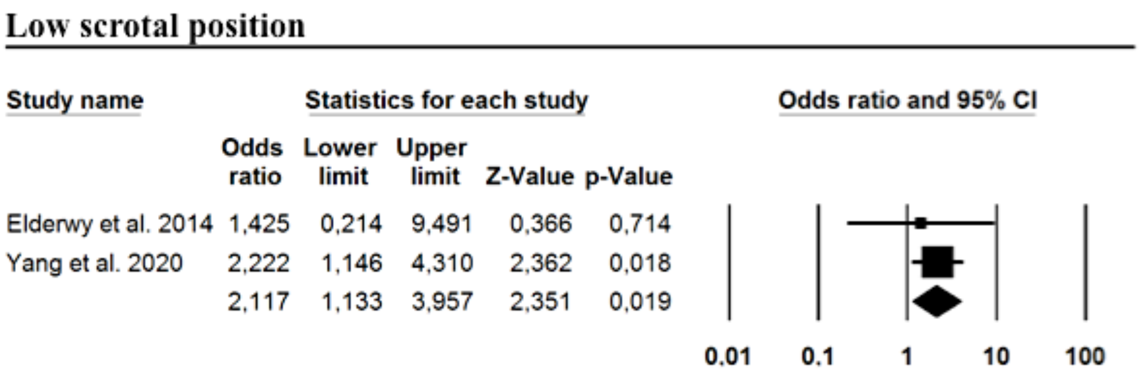


Figure 9. Meta-analysis of success and low scrotal position between laparoscopic orchiopexy (LO) and open orchiopexy (OO). The table at the top of the figure shows the rates of a

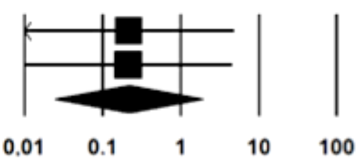
successful outcome and of a successful outcome associated with a low scrotal position for the two techniques in each comparative study. The graphs below the table show the forest plots of the odds ratio (95% confidence intervals, CI) of success and of low scrotal position for testes repaired with LO compared with testes repaired with OO. For success, the odds ratio for the two included comparative studies equals 4.59 (95% CI 0.52-40.19) with a *p* value 0.16, indicating no evidence of an overall difference between LO and OO. For low scrotal position, the odds ratio for the two included studies equals 2.11 (95% CI 1.13-3.95) with a *p* value 0.02 in favour of LO. The latter pooled result is mainly influenced by the study by Yang et al. 2020, as indicated by the larger respective box (likely related with the bigger sample size and narrower CI) compared with the small box corresponding to the study by Elderwy et al. 2014.

Studies	Recurrence n/N (%)		Atrophy n/N (%)		Overall complications n/N (%)	
	LO	OO	LO	OO	LO	OO
Escarcega-Fujigaki 2011	0/38	0/37	0/38	0/37	0/38	1/37
Elderwy 2014	0/21	2/25	0/21	0/25	1/21	4/25
Yang 2020	0/140	2/154	0/140	0/154	3/140	6/154
Total	0/199 (0%)	4/216 (1.9%)	0/199	0/216	4/199 (2%)	11/216 (5.1%)

Recurrence

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Elderwy et al. 2014	0,219	0,010	4,815	-0,964	0,335
Yang et al. 2020	0,217	0,010	4,561	-0,983	0,326
	0,218	0,025	1,907	-1,377	0,169

Odds ratio and 95% CI



Overall complications

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Escarcega-Fujigaki et al. 2011	0,316	0,012	8,009	-0,698	0,485
Elderwy et al. 2014	0,263	0,027	2,554	-1,152	0,249
Yang et al. 2020	0,540	0,133	2,202	-0,859	0,390
	0,425	0,138	1,304	-1,496	0,135

Odds ratio and 95% CI

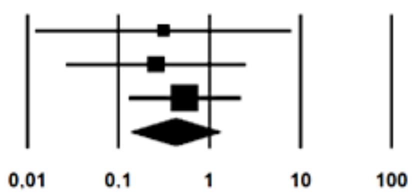


Figure 10. Meta-analysis of recurrence, testicular atrophy and overall complications between laparoscopic orchiopexy (LO) and open orchiopexy (OO). The table above shows the rates of

testis reassent, atrophy and overall complications for the two techniques in each comparative study. The graphs below show the forest plots of the odds ratio (95% confidence intervals, CI) of recurrence and of overall complications for LO and OO. Testis atrophy was not included in meta-analysis, as respective rates were all equal to zero.

The operative time was overall longer with laparoscopic orchiopexy, but only with marginal significance (average SMD=0.21, *p*=0.05) (**Figure 11**). Similarly, although not possible to be meta-analyzed for data provided by most authors were insufficient, the cost was evidently higher with laparoscopic orchiopexy by 15%-25% in all studies [Elderwy AA *et al.* 2014, Escarcega-Fujigaki P *et al.* 2011, Yang *et al.* 2020]; when a difference in means by 16% was statistically compared, it proved significant at the level of 0.001 [Yang *et al.* 2020].

Studies	Operative time (min)		Cost	
	LO	OO	LO	OO
Escarcega-Fujigaki 2011	45	38	15% above OO	Not reported
Elderwy 2014	40±3.7	40±7.4	25% above OO	Not reported
Yang 2020	62.5±15.2	59.0±13.3	8357±485 RMB	7004±310 RMB

Operative time

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Elderwy et al. 2014	0,000	0,296	0,088	-0,580	0,580	0,000	1,000
Yang et al. 2020	0,246	0,117	0,014	0,016	0,476	2,097	0,036
	0,213	0,109	0,012	-0,001	0,426	1,950	0,051

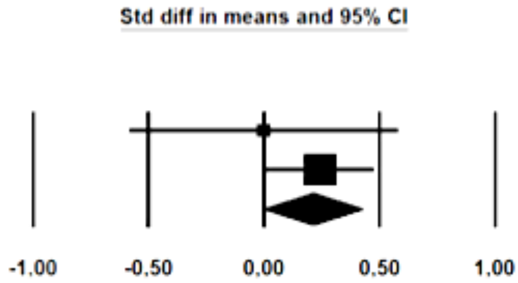


Figure 11. Meta-analysis of operative time and cost between laparoscopic orchiopexy (LO) and open orchiopexy (OO). The table at the top shows operative time (presented as median or

as mean ± standard deviation) and cost (% difference in medians or mean ± standard deviation) for the two techniques in each comparative study. The graph below shows the forest plot of standardized difference in means (95% confidence intervals, CI) of operative time for LO in comparison with OO. The operative time is comparable between the two techniques in the first included study (p=1.0), and significantly longer in LO than in OO in the second included study (p=0.04). The average standardized difference for the two studies combined is 0.21 (95% CI -0.001 – 0.43) with a p value of 0.05, indicating only marginal significance in the operative time between the two techniques when all available data were combined.

2.4 INTERPRETATION AND DISCUSSION OF FINDINGS

Our study showed overall success and complications rates of 99.7% and 0.7%, respectively, with laparoscopic orchiopexy in the management of palpable undescended testes. Success rates were not affected by regular high dissection, Prentiss maneuver or transcrotal fixation. On the other hand, regular high dissection and Prentiss maneuver were associated with higher complications rates. Comparison of laparoscopic with open orchiopexy showed that safety and efficacy of the two methods is comparable for palpable undescended testes, as there was no evidence of significant differences in success, recurrence, testis atrophy and overall complications rates. Findings indicating a lower scrotal position, marginally longer operative time and higher cost for laparoscopic orchiopexy need further study.

The main advantage of laparoscopy is that it allows high dissection of the spermatic vessels in the retroperitoneum [Yang Z *et al.* 2020]. This is particularly useful in intrabdominal testes, whose orchiopexy requires extensive mobilization. Accordingly, laparoscopy is generally preferred for the management of nonpalpable testes [Jordan GH & Winslow BH 1994, Lindgren BW *et al*. 1998, Radmayr C *et al.* 2003], despite the presence of studies, including a meta-analysis, indicating no clear evidence for a benefit-cost ratio in favour of laparoscopic orchiopexy, as opposed to available open techniques [Dhanani NN *et al.* 2004, Ferro F *et al.* 1999, Guo J *et al.* 2011]. However, unlike intrabdominal testes, inguinal testes do not usually require extensive high dissection. In a study on laparoscopic orchiopexy of palpable undescended testes, only 38% of the cases necessitated retroperitoneal dissection [He *et al.* 2008]; unfortunately, it was not specified whether these testes were high-positioned. In any case, laparoscopy was probably unnecessary in 62% of the cases. Furthermore, our study did not show any difference in success rates with regular high retroperitoneal dissection, indicating no evidence for a clear benefit of laparoscopy in all palpable testes regardless of their position.

Another popular advantage of laparoscopy is the easy rerouting of the testis through a shorter pathway towards the scrotum by the medial side of the inferior epigastric vessels using the Prentiss maneuver [Yang Z *et al*. 2020]. However, our study showed no difference in success rates between studies using Prentiss maneuver and studies using the inguinal canal route, indicating that Prentiss maneuver is probably not necessary to bring down palpable testes. Furthermore, regular high dissection and Prentiss maneuver are likely an unnecessary extra risk for morbidity in these patients, as they were both associated with higher rates of complications, including scrotal hematomas, wound infection and bleeding from the epigastric vessels. Use of different tools to scrotalize the testis or epigastric vessels clipping prior to Prentiss maneuver did not appear to reduce this risk.

To our knowledge, there are only three comparative studies between laparoscopic and open orchiopexy in palpable testes [Elderwy AA *et al*. 2014, Escarcega-Fujigaki P *et al* 2011, Yang Z *et al*. 2020]. In the latest one, the authors claim an increased risk of recurrence and testis malposition with open orchiopexy [Yang Z *et al*. 2020]. However, the same authors documented no significant difference in comparisons of success, recurrence and redo orchiopexy rates between laparoscopic and open technique. Likewise, our meta-analysis including all available data from all previous comparative studies showed no significant difference in the pooled rates of success and complications between laparoscopic and open orchiopexy; both procedures were successful in more than 98% of cases. At the same time, all three comparative studies reported higher cost for laparoscopic orchiopexy by 15-25% [Elderwy AA *et al*. 2014, Escarcega-Fujigaki P *et al* 2011, Yang Z *et al*. 2020]; unfortunately, insufficient statistical data in two of the available studies did not allow meta-analysis of the cost. The operative time was marginally longer with laparoscopic orchiopexy in our meta-analysis, and laparoscopic orchiopexy definitely included a learning curve with longer operative times in the first, at least, 15 cases [Escarcega-Fujigaki P *et al* 2011]. Statistical comparisons of operative time and cost between laparoscopic and open orchiopexy should be included in future studies, in order to draw safe conclusions about the actual benefit-cost ratio of laparoscopic orchiopexy.

In the comparative study by Yang et al. [Yang Z *et al*. 2020] (evidence level III), a significantly increased rate of a more favorable scrotal position was noted with laparoscopic orchiopexy. However, this finding was not confirmed in the randomized trial by Elderwy et al. [Elderwy AA *et al*. 2014] (evidence level II); in the latter, despite the high position of the peeping testes included, the scrotal position was comparable between laparoscopic and open technique. Our meta-analysis, including both studies, revealed a significant difference in the rate of low scrotal position between the two methods. This result, however, should be interpreted cautiously, as it was mainly impacted by the study by Yang et al., probably due to its larger sample size. A randomized controlled trial with an adequately large sample size would be required, to draw safe conclusions about whether laparoscopy might be an actual aid to achieve more favorable scrotal position for palpable undescended testes.

2.5 STUDY LIMITATIONS AND STRENGTHS

Our systematic review and meta-analysis are limited by the small number of available studies. Moreover, our meta-analysis is at evidence level III, as two of the three available comparative studies were non-randomized. However, our study offers a more precise estimate of the outcomes than either of the available studies alone. It also reveals that late claims that open orchiopexy of palpable testes is associated with higher rates of testis malposition than laparoscopic orchiopexy are not based on the evidence available in the literature to date.

3. CONCLUSIONS AND SUGGESTIONS

Combined results of all available studies show that laparoscopic orchiopexy does not have a clear advantage over open orchiopexy for palpable undescended testes with respect to success and complications, while it is associated with higher cost than open orchiopexy in all available studies. High retroperitoneal dissection and Prentiss maneuver proposed as the main benefits of laparoscopic orchiopexy by its advocates were found to be unnecessary as well as a likely cause for extra morbidity in a significant number of palpable testes. Testis intrascrotal fixation, likely harmful for the testis, is not necessary. A possibly higher benefit-cost ratio, related with a possibly lower scrotal position, with laparoscopic orchiopexy needs to be further investigated, while controlled for the likely confounding role of initial testis position (high- vs. low-positioned inguinal testes), in future randomized controlled trials.

It can be derived from the above that laparoscopic orchiopexy remains the best quality care for patients with palpable undescended testes and the best value for money for the health system at the same time. Therefore, current guidelines [EAU Guidelines on Pediatric Urology 2018] should not be amended, despite recent suggestions by some authors [Yang Z *et al.* 2020], and classic open transinguinal orchiopexy should be recommended as the procedure of choice for palpable undescended testes. Laparoscopic orchiopexy can be alternatively used in palpable undescended testes, as it shows the same safety and efficacy with open orchiopexy. However, it should include extensive retroperitoneal dissection, Prentiss maneuver and intrascrotal testis fixation only when necessary.

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