Laparoscopic descent with preservation of testicular vessels for intra-abdominal testis: A quasi-experimental study.

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1.- Research Question

What is the efficacy and safety of laparoscopic testicular vessel-sparing techniques for intra-abdominal testicular descent?

Hypothesis:

- The VILO technique will be effective and safe, with a success rate of over 90% and the presence of testicular atrophy of less than 5%.
- The Shehata technique will be effective and safe, with a success rate of over 90% and the presence of testicular atrophy of less than 5%.

2.-Summary:

Introduction: Cryptorchidism is the absence of one or both testicles in the scrotum; it is the most common congenital genital pathology identified at birth. The surgical treatment, orchidopexy, consists of repositioning the testicle in the scrotal pouch. Thirty percent of the cases correspond to "non-palpable testicles", which will require a diagnostic laparoscopy, which is considered the treatment of choice for diagnosing and treating these cases. A treatment is considered effective and safe when the testicle is able to descend into the scrotal sac without atrophy. The extreme scenario of cryptorchidism is intra-abdominal testicles with short testicular vessels, which makes primary descent impossible. For these cases, the technique proposed by Fowler-Stephens has been developed, which involves the section of the testicular vessels so that in a second surgical stage, the descent can be achieved. This technique is not free of complications; among the most frequent complications is testicular atrophy. For this reason, the Shehata technique was developed, recently described in 2008, associated with a percentage of efficacy and safety of 100%, with respect to scrotal descent without testicular atrophy, as long as a transoperative maneuver is performed to determine the length of the vascular pedicle, and consequently, the procedure to be performed (VILO vs. Shehata). However, there is not enough evidence to evaluate the relevance of this maneuver.

Justification: Diagnosing and managing this pathology has evolved positively in the last 50 years. The extreme scenario corresponds to intra-abdominal testicles, where the length of the gonadal vessels is the limiting factor to achieve descent to the scrotum in a single surgical time, without tension and without testicular atrophy

Laparoscopic techniques with preservation of testicular vessels could be the future for the correction of those patients with intra-abdominal testicles.

Research protocols are necessary to improve the future fertility of patients through intrascrotal repositioning of the intra-abdominal testis.
standardized and prospective studies where the safety and efficacy of testicular vessel sparing techniques can be evaluated to generate evidence for future decision making.

Main objectives

- To determine the safety and efficacy of the laparoscopic Shehata technique for intra-abdominal testicular descent.

- To determine the safety and efficacy of the laparoscopic VILO technique for intra-abdominal testicular descent.

Material and Methods: Patients aged 6 months to 7 years, with intra-abdominal cryptorchidism corroborated by laparoscopy, non-syndromic, uni or bilateral, who, depending on the length of the testicular pedicle (without randomization, quasi-experimental study), will undergo a laparoscopic descent with preservation of testicular vessels, either a primary descent (VILO) or by the technique of elongation and delayed descent (Shehata). Six months after surgery, by means of ultrasonography and clinical examination, testicular atrophy (safety) and intrascrotal placement (efficacy) will be determined, with the same subject being monitored before and after the operation

3.- Theoretical Framework:

3.1. Introduction

Cryptorchidism comes from the Greek words kriptos, hidden/occult, and orchis, meaning testicle; the term "undescended testicle" is synonymous with cryptorchidism. The normal position of the testicle is in the scrotum, in its middle third or below. Diagnosing and managing this pathology has evolved positively in the last 50 years.

Definition: It is the absence of one or both testicles in their normal position, represents the failure of testicular descent that do not reach their final, intrascrotal position(1) ; and is classified as congenital, if the testicle is outside the scrotum from birth.

It is the most common congenital genital pathology identified at birth(1) , characterized by the absence of one or both testicles in the scrotal sac. It occurs in approximately 3% of term newborns and up to 30% in preterm patients; most are not syndromic(3) . If cryptorchidism is not treated correctly, the repercussions can result in potential medium and long-term complications in fertility issues(4, 5) , testicular cancer(6) , testicular torsion(7) , inguinal hernia(4) , and even psychological aspects(8) . The surgical treatment, orchidopexy, consists of repositioning the testicle inside the scrotal sac, in its middle third. Early correction is very important, as it significantly improves the fertility of patients(9) . There are different severity spectrums, being the high intra-abdominal testicles, with very short testicular vessels that make the primary descent impossible, so they will require at least 2 surgeries to achieve the descent to the scrotum.

The process of normal testicular descent has not been fully understood(2) , but any disruption will result in cryptorchidism, a spectrum with varying degrees of complexity and severity.

Embryology.

During weeks 6-7 of gestation, under the **effects of the SRY gene,** the bipotential gonadal tissue located in the genital ridge begins to differentiate into testis. Under the influence of this gene, the cells of the medullary region form testicular epithelial cords in which Sertoli cells differentiate in association with primordial germ cells that migrate into these cords. Sertoli cell differentiation only occurs if the SRY protein is present. Otherwise, the sex cords would form ovarian follicles. These primitive testicular cords contain germ cells that eventually canalize and differentiate into seminiferous tubules, in which sperm will be produced. Direct contact between developing Sertoli cells and primordial germ cells is thought to play a key role in the development of male gametes, an interaction that occurs shortly after the arrival of primordial germ cells at the genital ridge. The testicular cords distal to the seminiferous tubules also develop lumina and differentiate into a set of thin-walled ducts called *the rete testis*, just medial to the developing gonad. The tubules of the rete testis connect with 5-12 residual mesonephric tubules that will form the efferent ducts and transport the sperm to the head of the epididymis. The epididymis and vas deferens develop from the Wolffian duct.(10)

As the developing Sertoli cells begin to differentiate in response to the SRY protein, the secretion of Müllerian inhibitory substance (MIS) also begins. MIS causes the paramesonephric (Müllerian) ducts to rapidly involute between the eighth and tenth week of gestation, leaving small testicular appendages that are nothing more than involuted Müllerian remnants, in addition to the prostatic utricle.
(10).

In response to SRY protein during the 9th and 10th week of gestation, Leydig cells differentiate from the mesenchymal cells of the genital ridge. These endocrine cells produce testosterone. In development, testosterone secretion is regulated by placental chorionic gonadotropin, but fetal pituitary gonadotropins eventually take over control of androgen production. Between weeks 8 to 12, testosterone secretion from the Leydig cells stimulates the mesonephric (Wolffian) ducts to transform into pairs of epididymis, vas deferens, and seminal vesicles, while the cranial portions of the mesonephric ducts degenerate, leaving a small cystic remnant called the epididymal appendage. During week 9, 5 to 12 tubules make contact with the testicular network in the epididymal region. However, it is not until the third month that communication is established between the seminiferous tubules, the testicular network, the efferent ducts, and the epididymis. In the meantime, the mesonephric tubules near the lower pole of the testis degenerate, leaving epithelial remnants called paradidymis. (10)

Gonadal descent

Testicular descent occurs in 2 phases: transabdominal and transinguinal.

The **transabdominal phase** occurs between 7 and 15 weeks of gestation(10) . Morphologically at 7 to 8 weeks of gestation, the urogenital ridge of humans is identical in both sexes. Before gonadal differentiation, the testis is located near the developing kidney in the upper part of the lumbar region, attached by two ligaments: the cranial suspensory ligament (in the cephalic part) and the Gubernaculum in the caudal part. Between weeks 10 to 15 during the enlargement of the abdominal cavity, the testicle descends to the inguinal region, thanks to the widening of the Gubernaculum and the involution of the cranial suspensory ligament(10) . Androgens are responsible for the involution of the cranial suspensory ligament. Gubernaculum widening occurs independently of androgen activity, based on the fact that this occurs in androgen-resistant mice and humans. (10)

From the seventh month, the gubernaculum prolapses beyond the external inguinal ring extending towards the scrotal region; simultaneously it is hollowed out by the diverticulum of the vaginal peritoneum, called "vaginal process". The vaginal process will allow the passage of the intra-abdominal testis through the inguinal region and out of the abdominal cavity(10) . The inguinoscrotal descent requires the Gubernaculum to migrate a considerable distance, along with the increased length of the vaginal process. The force for migration comes from intra-abdominal pressure, transmitted directly and indirectly to the testis, through the lumen of the vaginal process and gubernacular cord respectively. (10)

The second migratory step, the inguinoscrotal phase, is believed to be androgen-dependent. The transinguinal descent ends at 35 weeks of gestation. Androgens act indirectly through the genitofemoral nerve, which produces calcitonin gene-related peptide (CGRP), to control the direction of testis migration(10) . Regression of the gubernacular bulb also appears to be androgen-dependent, since after completion of scrotal descent, the gubernaculum remains enlarged in humans with androgen resistance.

Insulin-like/analogous peptide 3 (INSL3) was identified as a novel gene product of Leydig cells. It is similar in structure to the peptide hormones relaxin or insulin and is expressed in fetal and adult Leydig cells in a differentiation-dependent manner. Mice lacking a functional INSL3 gene show intra-abdominal cryptorchidism but no obvious defects in other male reproductive organs. More importantly, early surgical correction of cryptorchidism in these mice restores normal fertility potential. These findings are important because they reflect the phenotype most commonly observed in classic human cryptorchidism. (10)

3.3. Testicular Irrigation

The arterial irrigation of the testicle is conditioned by 3 Arteries(11) : 1) the testicular artery, or gonadal artery, (of cephalic origin), 2) the deferential artery (from the vas deferens), and 3) the cremasteric artery, or external spermatic artery, as shown in Figure 1 .(11)

Figure 1.

The main arterial supply of the testis is provided by 1) the testicular artery (a. gonadal). The artery's origin comes directly from the abdominal aorta, immediately below the renal arteries, so its origin is cephalad to the internal inguinal orifice. It then descends obliquely towards the internal inguinal orifice, crosses the ureter and the psoas, enters the inguinal canal, and descends to the scrotum, ending at the posterior aspect of the testicle and epididymis. In its course, it gives branches to the ureter, the adipose capsule of the kidney, and the elements of the cord.

2) The deferential artery originates from the inferior vesical artery, which, in turn, is a branch of the internal iliac or hypogastric artery. The deferential artery normally ascends together with the vas deferens, until it enters the internal inguinal orifice, to descend together with

the rest of the elements of the cord until it reaches the posterior border of the testicle (normal anatomy). Normally, the deferential artery enters the internal inguinal orifice forming an "ascending-descending loop" until it reaches the testicle normally implanted in the scrotum. The origin of the artery is caudal to the internal inguinal orifice; therefore, in most cases, the length of this vessel is not a problem for testicular descent, which is why, as we will see below, the Fowler-Stephens technique uses it as the only final irrigation for testicular descent.

3) The cremasteric artery originates from the inferior epigastric artery and supplies the cremasteric muscle, which is part of the cord elements.

These 3 arteries are anastomosed near the testicle. There are anastomoses between the testicular vessels and the vas deferens; all patients have good anastomoses between the testicular/gonadal and vas deferens arteries. There are also some anastomoses between these and the cremasteric arteries in approximately two-thirds patients; additional anastomoses appear to exist between the testicular, cremasteric and scrotal vessels.

3.4. Classification

The testicle is not a fixed structure but presents a cephalic-caudal movement as a result of the cremasteric reflex and the contraction of the Dartos muscle, and it is a normal finding in all prepubertal boys. Also, the movement is a consequence of its position within the peritoneal-vaginal process, mainly when it is located in the superficial inguinal pouch, at the level of the external inguinal ring, in such a way that the testicle can move within the vaginal process.

Based on the clinical examination, it is said to be a **"palpable testicle"** if, by means of a physical examination, with clinical maneuvers and without sedation, it is possible to palpate and determine its position, or it is a **"non-palpable testicle"** when it was impossible to locate it in the inguinal canal or in the scrotum; this is important, since the surgical approach to be followed will depend on this . (1)

There are some entities to consider.
Evanescent testicle: Initially, there was the presence of a testicle, but in the development, it suffered some vascular accident, resulting in the loss of the testicle. During a laparoscopy, the patient shows that at the confluence of the deferens with the testicular artery, there is only an outline of gonadal vessels, without the existence of the testicle.(10)
Testicular Agenesis: Refers to the fact that there has never been the formation of a testicle, with absence of spermatic vessels and vas deferens, and therefore is associated with ipsilateral persistence of the Müllerian duct. (10)
Congenital cryptorchidism: The absence of a testicle in the scrotum from birth.(10)

Acquired Cryptorchidism: A cryptorchid testicle that previously had a documented normal position within the scrotum, but later, secondary to the individual's growth, the testicle ascended and is now palpable outside the scrotum.(2)
Retractile testicles: Refers to those testicles that at the time of examination are outside the scrotum but that can be located and that can easily descend into the scrotum and, when released from traction, remain in the scrotum.(1)
Canicular testis: The testis is lodged in the inguinal canal, covered anteriorly by the aponeurosis of the external oblique muscle. The spermatic vessels and the vas deferens enter the internal inguinal orifice, with or without direct vision of the testicle.(10)
Peeping" **testicle** refers to that intra-abdominal testicle lodged at the level of the internal inguinal ring, associated with a permeable vaginal peritoneal process, that as soon as CO2 is insufflated into the abdominal cavity, the testicle moves towards the inguinal canal and it is when it is palpated externally, in the inguinal region. It is considered as intra-abdominal and the ideal is to manage it with a laparoscopic orchidopexy.(2)
Intra-abdominal cryptorchidism: In this scenario, the testicles are located within the abdominal cavity or just inside the internal inguinal orifice and are clinically not palpable. (10)

Approximately 70% of cryptorchid testicles are palpable, the rest are "non-palpable," and more than 50% are intra-abdominal.(12, 13)

3.5. Incidence

Epidemiology: The incidence of cryptorchidism in preterm patients weighing less than 2.5kg is 45% and decreases to 4.6% in term patients weighing more than 2.5kg(14) . 80-85% of cases with cryptorchidism are isolated, i.e., they are NOT syndromic.(3)

The incidence of cryptorchidism is 45% in preterm infants weighing less than 2.5kg and decreases to 4.6% in term infants weighing more than 2.5kg. The majority, 80-85%, of cryptorchidism is isolated, i.e., "non-syndromic cases."

Etiology: There is no specific cause for cryptorchidism, being unknown in most cases, suggesting that it is a heterogeneous, multifactorial pathology, with multiple risk factors, genetic and environmental(3, 15) . Genetically, there is an associated component(16) ; a risk of 2.3 and 3.5 times higher probability of occurrence in children with family history(17) has been calculated. Among the environmental factors with estrogenic effects or that interfere with androgen synthesis and action. Exposure to pesticides has been cited(18) seen in those mothers exposed to these agents as in agriculture, horticulture, or in places with high pesticide use. It has also been seen in those with exposure to diethylstilbestrol(19) , pre-eclampsia/eclampsia,(19, 20) , pre-gestational and gestational diabetes(19, 21) , smoking(22) , associated with consumption of analgesics during gestation(23) , as well as advanced maternal age . (24)

3.6. Consequences of cryptorchidism

The repercussions can result in potential medium and long term complications in terms of: fertility(4, 5) , testicular cancer(6) , testicular torsion(7) , inguinal hernia(4) even psychological aspects(8) if it was not treated correctly.

Malignancy

In relation to the risk of testicular cancer, the inherent risk of malignant degeneration of an undescended testicle is widely recognized, and the overall relative risk of developing cancer for having presented cryptorchidism is 2.7 - 8 times(28) , 10% of adults with testicular cancer have a history of cryptorchidism(32) . A history of cryptorchidism increases the risk of developing testicular cancer by 2 to 8 times(25) ; it varies depending on its location. It varies from 1% in inguinal testicles and 5% in intra-abdominal(26, 27) . Early corrections are associated with a decreased risk of developing cancer compared to those corrected after puberty(33, 34) . Evidence indicates that it decreases when corrected before puberty, representing a 2 - 6-fold reduction in relative risk compared to postpubertal orchidopexy. Of the neoplasms, seminomas are the most frequent in intra-abdominal cryptorchidism(28, 29) and non-seminomas in those who have undergone successful orchidopexy.(30, 31)

Fertility

It has been demonstrated that the affectation of fertility in patients with a history of cryptorchidism is present in variable degrees, being more affected those cases of bilaterality, intra-abdominal testicles, as well as those operated late. Thus, the current trend is to correct the problem before 12 months of age.(35)

Uncorrected testes, particularly those that are not palpable, are at increased risk for ongoing germ cell and Leydig cell loss(36) ; the duration of this condition correlates with higher rates of germ cell loss and infertility in adulthood(37-39) , as well as more testicular fibrosis(40, 41) . These histological changes are associated with abnormal semen parameters in adulthood(42, 43) , suggesting that cryptorchidism is a progressive disease rather than a static congenital malformation.(44)

3.6.3. Inguinal Hernia

The presence of a permeable vaginal peritoneal process is very variable, it is present in 20-73% of the cases(45, 46) , even, there are works in which they have found the presence of a permeable vaginal peritoneal process with alterations in the deferens, independently of the position of the testicle(47) . An open internal inguinal ring is an area of weakness of the pelvic floor, which predisposes to the development of an inguinal hernia; for these reasons, at the time of cryptorchidism correction, a permeable vaginal peritoneal process must be closed.

3.6.4. Testicular Torsion

Testicular torsion can occur in patients with cryptorchidism, who do not have a normal testicular descent and therefore have a poor fixation of the Gubernaculum, the normal distal fixation element, so they have a higher risk of suffering a testicular torsion(7) ; so orchidopexy also prevents this potential and catastrophic complication.

3.6.5. Other associated anomalies

Patients with cryptorchidism present other alterations that interfere with their future reproductive capacity. Among these, we have defects of the junction of the epididymis with the testis, present in 16-75%(48) . These anomalies correlate with the degree of severity of cryptorchidism and the degree of permeable peritoneo-vaginal process(47) , being more frequent the complete separation of the epididymis from the testicle in those intra-abdominal(49) . All these epididymal abnormalities potentially contribute to subfertility in patients with a history of cryptorchidism.

3.7. Diagnosis

The diagnosis of cryptorchidism is made by genital physical examination in a warm environment. Infants are examined in the supine position, with the legs in the frog position, beginning with inspection of the shape, size, coloration and grooves of the scrotal pouch, the presence or absence of enlargement at the inguinal level, the size of the penis and the presence of deformities of the urethral meatus. With one hand, gentle downward pressure is applied along the inguinal canal. On the other hand, the affected testicle is explored, as well as the contralateral testicle. In patients with monorchidism, it is common to find the presence of compensatory hypertrophy. A hypoplastic scrotum implies that the testicle is not present inside the scrotum. It is **important** to correctly **classify** cryptorchidism as ***palpable*** and ***non-palpable testicle***, as it will determine the surgical approach (See Figure 2)(1) . A "non-palpable testicle" is a clear indication for surgical exploration.(50)

Clinical practice guidelines indicate that prior to referral of the patient to the surgeon, it is not necessary to perform diagnostic imaging studies(1) since, in experienced hands, 70% of the testes correspond to "palpable testes" and the remaining 30% to non-palpable testes. Ultrasound has a sensitivity and specificity for localizing non-palpable testes of 45% and 78%, respectively(51) ; this study accurately determine the presence or absence of an evanescent testis. Regarding computed axial tomography, it is a study with ionizing radiation and is, therefore, not indicated as a diagnostic study for a non-palpable testicle in the pediatric population. Regarding Nuclear Magnetic Resonance Imaging, it requires general anesthesia to perform it(52-56) and it is not available in all centers; so that a non-palpable testicle is an indication to perform a surgical exploration, since no imaging study can conclude with 100% certainty the absence or presence of testicle (evanescent testicle).

Clinical practice guidelines indicate that all newborns with a history of cryptorchidism detected at birth, and those who have not spontaneously descended during the first 6 months of life (corrected for gestational age), should be referred to a surgeon for a timely evaluation(50, 57) . Because after 6 months, the probability of spontaneous descent is very low, and histological damage to the testis outside the scrotum continues. The results of a clinical trial in which early correction was performed at 9 months of age vs. 3 years of age showed better testicular growth in those patients operated on early .(9)

Figure 2.

In prepubertal patients with undescended testicles in whom conventional clinical examination fails to palpate the testicle, an examination under anesthesia should be performed to determine exactly whether the testicle is palpable or not(1) . Of these patients, up to 18% can be palpated under anesthesia(58) . If palpation is achieved, open orchidopexy is performed through an inguinal, scrotal, or mixed approach. In those where palpation was not achieved, abdominal exploration should be performed either laparoscopically or by open surgery. (1)

Laparoscopic surgery is the method of choice for a non-palpable testis(58, 59) . It allows the surgeon to inspect the retroperitoneum with minimal morbidity and perform a thorough search along the path of the normal embryologic descent, which runs perineal to the internal inguinal foramen.

We have 4 clinical scenarios that can be encountered during laparoscopy.

1) The deferens and testicular vessels are observed entering the closed internal inguinal orifice, indicating that the testicle is in the inguinal canal. Therefore, the procedure should be continued with an open inguinal exploration to perform the orchidopexy, a scenario that occurs in up to 34% of cases.(58)

2) You find an **evanescent testicle**. Laparoscopically, the confluence of the vas deferens and spermatic vessels is observed, but there is no testicle, so surgical treatment is concluded.

3) If you find a **hypoplastic or dysgenesis testicle**, the procedure will consist of removing it, as long as the contralateral testicle is located in the scrotum and has a good volume.

4) You find the testicle not dysgenesis, of good size. In this case, a laparoscopic orchidopexy is performed. The technique for descent is currently strongly influenced by the surgeon's preference. However, the main factor should be the length of the testicular vessels. If the length of the testicular vessels allows it, a primary orchidopexy (**VILO**) is performed, but in case the testicular vessels are very short and do not allow descent into the scrotum, an orchidopexy is performed with the **Fowler-Stephens** technique or according to the **Shehata** technique. Thus, the main limitation to performing a primary orchidopexy is the length of the vascular pedicle.

With this we conclude that a laparoscopy has 2 functions: 1) diagnostic, i.e., it locates the non-palpable testicle, 2) therapeutic, as a minimally invasive method to perform an orchidopexy.

3.8. Treatment

Indications and surgical time.

The main reasons for managing cryptorchidism are the increased risk of potential fertility impairment, testicular malignancy, testicular torsion, and associated inguinal hernia. Successful orchidopexy may reduce but not prevent possible long-term sequelae in susceptible individuals.

Uncorrected testes, particularly those that are not palpable, are at increased risk for continued germ cell and Leydig cell loss(36) . The duration of this condition correlates with increased germ cell losses, infertility in adulthood(37-39) , and increased testicular fibrosis(40, 41) . These histological changes are associated with abnormal semen parameters in these patients in adulthood(42, 43) , suggesting that cryptorchidism is a progressive disease, not a static congenital malformation.(44)

The current recommendation is that patients 6 months of age who persist with cryptorchidism should be corrected within the next 12 months(59, 60) , although the trend is towards correction during the first year of life, as it favors testicular growth and decreases histological damage.(35, 61)

Medical Management:

Hormonal therapies have been associated with side effects, so they are not recommended to stimulate testicular descent as a treatment for cryptorchidism in boys.(1, 50)

Medical treatment has limited benefits, which have not been significantly positive. Studies indicate that Luteinizing Hormone-Releasing Hormone (LHRH) therapy is marginally more effective than placebo.

Other uses of Human Chorionic Gonadotropin Hormone (hCG), include treatment of acquired cryptorchidism and improving "palpability" and treatment of abdominal testicles(62, 63)

Human Chorionic Gonadotropin Hormone (HCG) stimulates androgen production through Leydig cell activity. Its action is virtually identical to pituitary LH activity. Its use offers limited efficacy. Studies have not shown long-term efficacy, with a high risk of recurrence. Adverse effects occur in up to 75% of children. They include increased scrotal folds, scrotal hyperpigmentation, appearance of pubic hair, and penile growth. A total dose higher than 15,000 IU of HCG should be avoided as it may induce epiphyseal plate fusion and somatic growth retardation.(64)

The recognized side effects of Luteinizing Hormone Releasing Hormone (LHRH)/Gonadotropin Releasing Hormone (GnRH) therapy are less frequent than those observed with HCG. There is no long-term evaluation of LHRH treatment. As for HCG and GnRH, it has been reported that hormone treatment can damage germ cells in 1-3-year-old boys who did not respond to hormone treatment used to induce testicular descent.(65)

GnRH = Gonadotropin-releasing Hormone
FSH= Follicle Stimulating Hormone
LH= Luteinizing Hormone
LHRH = Luteinizing Hormone Releasing Hormone

Surgical Management

An effective and safe surgical treatment is defined as testicular repositioning in the scrotal sac (efficacy), without testicular atrophy (safety).(61)

The anatomical success rate in expert hands is 74% for abdominal testes, 82% for peeping testes, 87% for canalicular testes, and 92% for testes below the external inguinal ring(66) . The percentage of testicular atrophy is 3.3%, 6.9%, and 18.5% for testes in suprascrotal, canalicular (inguinal), and above the internal inguinal orifice positions, respectively.(67)

For those in which palpation is achieved, an inguinal or transscrotal orchidopexy is performed(60, 61) or by a mixed approach.

Diagnostic and therapeutic laparoscopy for the non-palpable testicle:

As mentioned, 70% of undescended testes are palpable on physical examination, not requiring at least imaging for diagnosis. The remaining 30% correspond to non-palpable testicles, where the challenge is to confirm the absence or presence of the non-palpable testicle, and to determine its location and characteristics.

If during diagnostic laparoscopy a non-dysgenic intra-abdominal testicle of good volume is found, it is corrected. Depending on the length of its gonadal vessels, any of the following 3 surgical treatments are performed:

1) Serial orchidopexy with the **Fowler-Stephens (FS)** technique in 2 stages
2) Vessel-preserving laparoscopic primary laparoscopic orchiopexy **(Vessel Intact Laparoscopic Orchiopexy) VILO**
3) 2-stage gonadal vessel-preserving serial laparoscopic traction orchidopexy **(Shehata).** (68, 69)

Thus, we can classify VILO and Shehata as laparoscopic techniques that preserve testicular vessels and the Fowler Stephens technique as the technique that involves the section of testicular vessels. Each of these techniques is detailed below:

1) **Fowler-Stephens (FS):** The method described in 1959(70) consists of cutting the gonadal vessels (testicular artery and vein) to allow the descent to the scrotum without tension so that the irrigation of the testicle will be only in charge of the deferential artery (Figure 3). Once the gonadal vessels are cut, it is expected to develop collateral irrigation and hypertrophy of the deferential artery so that, 6 months later in a second surgical time, it can be descended to the scrotum, without the limitation imposed by the short gonadal vessels that prevented its primary descent without tension. This method is limited to cases where the gonadal/testicular vessels are too short to allow descent into the scrotum without tension. However, it has been shown that there is a decrease in germ cells after sectioning the gonadal vessels.(71, 72)

Figure 3.

2) **VILO (vessel sparing primary laparoscopic orchidopexy):** This technique is only useful for patients with sufficient length of the vascular pedicle and deferens length to achieve descent of the testis in a single surgical time. The determination of sufficient length is considered if the testicle reaches the contralateral internal inguinal foramen without tension, as described in the figure(69) . For patients who do not have such length, the Shehata technique should be performed (Figure 1). Descending a testicle with a short vascular pedicle will ultimately result in the testicle being in a suboptimal position (suprascrotal), or with excessive tension that could result in testicular atrophy or recurrence of

cryptorchidism. In this technique, only the Gubernaculum is cut; the entire testicle is detached with the mesentery created with its gonadal vessels, the deferens, and its deferential artery(73) . After sectioning the Gubernaculum ligament, the peritoneum lateral to the gonadal vessels is cut and bluntly dissected, as well as the peritoneum covering the deferens, up to the supra vesical portion, detaching the testicle with all this peritoneal flap that includes the gonadal vessels and the deferens with its irrigation, making the testicle intra-abdominal reach the contralateral inguinal orifice making the dissected testicular pedicle touch the anterior abdominal wall (Figure 5). If such mobilization is achieved, it would theoretically have the necessary length to descend the testicle to the scrotum, through a paravesical neotray and medial to the ipsilateral inguinal ligament, which is shorter compared to the physiological trajectory of the inguinal canal.

3) **Shehata:** This technique is ONLY reserved for those testicles that have a short vascular pedicle, which prevents the primary descent into the scrotum without tension (Figure 5). This technique performs the same steps as VILO, ie: preserves the irrigation of the gonadal vessels and the irrigation of the deferens, but lacking sufficient length, the testis is temporarily fixed above the contralateral iliac crest, deferring descent into the scrotum for 12 weeks, waiting for the mesentery of the testicle (testicular artery, deferens and deferential artery) to elongate, with the abdominal movements of the patient and intestinal distension, so that in a second laparoscopic surgical time, it can be descended to the scrotum via the paravesical route. This technique has recently been described(68) , with the advantages of offering a superior length to that obtained by VILO while preserving the main irrigation of the testicle.

Figure 4.

The original **FS** approach was described as a single-stage open inguinal approach(70) . This one-stage approach resulted in severe hypoperfusion to the testicle, which was associated with a high rate of testicular atrophy of up to 32%(74) . This led to doing it in 2 stages(75) , decreasing testicular atrophy by 13%(76) and, in the best cases, by 6%(77) . The anatomical success of FS in terms of intrascrotal position is 83%.(78)

As for **VILO**, testicular atrophy has been reported to be greater than 5%(79, 80) . Preservation of testicular irrigation will always be preferred; however, many times before sectioning the Gubernaculum, it is technically difficult to determine if the final length of the mesentery of the vascular pedicle will be sufficient to achieve descent in a single time, which has led to suboptimal anatomical results with this technique in terms of reaching the position within the scrotum without tension(81) . The descent should be performed without tension to avoid retraction and hypoperfusion.(82)

At this time, there is no objective way to measure the necessary length of the vascular pedicle to achieve tension-free testicular descent. Some "indirect" trans-operative maneuvers have been described to predict whether the length of the vascular pedicle will be sufficient to descend the testicle into the scrotum without tension. Among them, there is the belief that if the affected testicle reaches to touch the contralateral internal inguinal foramen, it will be sufficient(83) . Another maneuver is the same, except that at the same time, the middle third of the pedicle should touch the abdominal wall, a maneuver described by Shehata(69) (Figure 5). It has also been said that if the testicle is more than 2cm away from the internal inguinal orifice, it is a candidate to perform a Fowler-Stephens descent(84) . Thus, up to this point, the issue of an objective measurement of the vascular pedicle has not been clarified.

Figure 5

Thus, those who do not achieve sufficient length should ideally undergo an orchidopexy with Shehata's principles, temporarily pexing the testicle on the contralateral side, above the iliac crest, so that 12 weeks later in a 2nd surgical time, the orchidopexy is completed, already with sufficient and appropriate length and irrigation. In such a way, that in a second time it cannot be considered a control ***** The original report by Shehata reported to be effective and safe in terms of anatomical success of 100% (efficacy), without testicular atrophy (safety).(85)

The final results of the surgery are evaluated 6 months after surgery, without tissue inflammation, allowing the evaluation of the anatomical success (final testicular position), viability, and testicular size. (79, 85)

In the INP, traditionally, the Fowler-Stephens technique has been performed. Personally, we have patients who have presented testicular atrophy after a Fowler-Stephens procedure. This has led me to look for another alternative to have better results, and in recent months, several patients have been operated on with this technique. So far, with good results, except for 2 patients who had to be operated on again because the testicle in the lapse of the 1st and 2nd surgery was detached intra-abdominally, so the length was not optimal for the final descent. I have also performed VILO. However, the limitation is that not all patients have sufficient length to perform the primary descent. I believe that it is necessary to implement and document what we are doing.

Prospective registries and standardized protocols are required to investigate the risks of testicular atrophy and address safety concerns associated with orchidopexy techniques.

4.- Problem Statement.

Cryptorchidism is the most common congenital genital pathology identified at birth, characterized by the absence of one or both testicles in the scrotal sac. It occurs in approximately 3% of term newborns and up to 30% in preterm patients, most of whom are not syndromic. The repercussions can result in potential medium and long-term complications such as fertility issues, testicular cancer, testicular torsion, inguinal hernia, and even psychological aspects if cryptorchidism is not treated correctly. The treatment is surgical correction (orchidopexy), which consists of repositioning the testicle inside the scrotal pouch.) 70% of cryptorchidism are "palpable testicles" which are repaired openly, but 30% of the cases correspond to "NON palpable testicles", which require diagnostic and possibly therapeutic laparoscopy.

Laparoscopic techniques with preservation of testicular vessels (Shehata and VILO) allow the intra-abdominal testicles to descend to the scrotal sac. This has the advantage of not sectioning the main irrigation of the testicles, which would have a positive impact on the future fertility of the patients.

5.- Justification

The diagnosis and management of this pathology have evolved positively in the last 50 years. The most extreme scenario corresponds to intra-abdominal testicles, where the length of the gonadal vessels is the limiting factor in achieving their descent to the scrotum in a single surgical time without tension and without testicular atrophy.

The laparoscopic technique with preservation of testicular vessels could be the future for the correction of those patients with intra-abdominal testicles.

Intrascrotal repositioning of the intra-abdominal testis will be essential to improving the future fertility of these patients, so standardized and prospective research protocols are necessary to evaluate the safety and efficacy of testicular vessel preservation techniques and generate evidence that will be useful for future decision-making.

6.- Objectives

Primary objective:

- To determine the safety and efficacy of the laparoscopic Shehata technique for intra-abdominal testicular descent.

- To determine the safety and efficacy of the laparoscopic VILO technique for intra-abdominal testicular descent.

7.- Hypothesis

- The VILO technique will be effective and safe, with a success rate of over 90% and the presence of testicular atrophy of less than 5%.

- The Shehata technique will be effective and safe, with a success rate of over 90% and the presence of testicular atrophy of less than 5%.

8.- Classification of the research.

This is a quasi-experimental before-and-after study. It does not have a control group, being the same subject the control before and after the intervention, without random assignment.

Study: quasi-experimental (analytical, experimental, prospective, and longitudinal).

Sampling: Non-probabilistic sampling

9.- Material and Methods

Target population: boys with non-syndromic cryptorchidism, uni- or bilateral.

Eligible population: Children with non-palpable testicle between 6 and 7 years old who are treated at the INP without previous treatment.

Inclusion criteria

- Patients with non-syndromic intra-abdominal cryptorchidism were corroborated by laparoscopy.
- Patients whose parents or guardians sign an informed consent form for their inclusion.
- Patients belonging to Mexico City or nearby areas who can attend the follow-up.

Exclusion Criteria:

- Patients with other concomitant genital anomalies (e.g., hypospadias).

Elimination Criteria:

- Boys with non-palpable testicle, to whom, during laparoscopy, it is corroborated that the deferens and testicular vessels enter the internal inguinal orifice, and that this is closed, corroborating by inguinal surgery the presence of a viable testicle, and that it can be descended via inguinal open approach.
- The patient who abandons the outpatient follow-up.
- Patients with evanescente testes.
- Patients with intra-abdominal dysgenic or atrophic testis.
- Subjects transferred to another institution.
- Subjects whose parents decide to leave the INP voluntarily.

Location: It will be performed in the department of General Surgery of the National Institute of Pediatrics. The patients will be recruited by the surgery outpatient clinic, with a diagnosis of cryptorchidism with non-palpable testicle, who will be invited to participate in the study after a medical evaluation by an assigned, which clinically corroborates the picture of a "non-palpable testicle". The parents of the participants will be explained the diagnosis of the patient. The diagnostic and therapeutic possibilities, as well as the follow-up they will have to follow, and their study protocol will be completed, which includes complete blood biometry, coagulation times, preoperative inguinoscrotal USG performed in the INP, with measurement of testicular volume, as well as the characteristics of the internal inguinal orifice, the inguinal canal bilaterally (healthy or diseased).

Classification of research

Quasi-experimental study

Sampling: Non-probabilistic sampling

Process

In patients with a non-palpable testicle, it will be scheduled for exploration under sedation in the operating room (**Figure 6**)

Anesthetic technique

After a preoperative anesthetic evaluation, the patient will go to the operating room to be explored under sedation with inhalation anesthesia with 1-5% sevoflorane. In those cases in which the diagnosis of non-palpable testicle is corroborated, a diagnostic laparoscopy will be performed under balanced general anesthesia (propofol 2mgkdo + opioid 2mckgdo + rocuronium 0.6mgkgdo), caudal block will be performed with administration of local anesthetic based on ropivacaine 2% at a rate of 2-3mg/kg of weight, and volume depending on the desired metamere to be achieved, will be calculated at a rate of 1.6ml to achieve the T4 metamere. Maintenance will be with anesthetic gas, sevoflorane at a CAM (Minimum Alveolar Concentration) of 2%.

Diagnostic and/or therapeutic laparoscopy

Diagnostic laparoscopy consists of placing a 5mm trocar via the umbilicus to introduce a laparoscopic lens and confirm the presence of the intra-abdominal testicle.

If the intra-abdominal location is confirmed, 2 more working trocars are placed on both flanks. The following measurements are then documented (**Figure 3**): a) Measurement of the emergence of the gonadal vessels in the posterior part of the abdomen (retroperitoneum), passing through the paravesical tract through which the testicle will descend, until reaching the middle 1/3 of the scrotum, with a suture (prolene vascular 2 zeros) which is introduced to the cavity, just above the pubis, in such a way that the cephalic end of this suture will touch the emergence of the gonadal vessels (retroperitoneum), and the caudal end will touch the middle 1/3 of the scrotum (A-A') See **figure 3**. This measurement will be very useful since it will determine if the final length of mobilization of the affected testicle will be optimal for its primary descent or if it will require a second time. This maneuver will be contrasted with the maneuver described by Shehata (**Figure 5, image 2**), as an evaluation of the length of the vascular pedicle.

At this point, a plain abdominal radiograph is taken to determine the distance between the gonadal vessels' emergence and the scrotum's middle third, along with a radiopaque ruler to document the distance radiographically.

A second measurement will be performed with a 2nd suture, which will be introduced percutaneously at the level of the contralateral inguinal orifice. The cephalic end will touch the same site of the emergence of the affected gonadal vessels, and the caudal end will be the contralateral inguinal orifice (B-B'). An additional measurement to this same measurement will be the additional length provided by the maneuver of touching the roof of the abdominal wall in the middle third of this distance (C-C'), as described by Shehata **(Figure 6, image 2**). These measurements will help us to contrast them with previously published maneuvers, and to see if they corroborate with our initial measurement (middle 1/3 of scrotum-emergence of gonadal vessels distance A-A').

Figure 6.

Likewise, the distance of the intra-abdominal testicle with respect to the ipsilateral internal inguinal orifice will be measured with the same technique (percutaneous), for statistical and documentation purposes, as well as the real dimensions of the testicle prior to its surgical mobilization, with a laparoscopic ruler.

Determination of VILO Vs Shehata:

The determinant for assigning the VILO Vs Shehata technique will be the length of the vascular pedicle measured transoperatively: During laparoscopy, after documenting the distances previously described, the Gubernaculum testis is cut to begin testicular mobilization, preserving the deferens, with its vasculature, as well as the gonadal vessels (gonadal artery and vein). The dissection/release of the lateral peritoneum covering the deferens extends to the bladder and the release of the peritoneum covering the gonadal vessels extends to visualize the ipsilateral deferens and the edge of the cecum, or the ascending colon, as the case may be. After this release of the affected testicle, it is insinuated in front of the orifice of the contralateral internal inguinal ring, while with another forceps (simultaneously), the midpoint of this mesentery testicular (deferens and gonadal vessels) is approached trying to touch the roof of the abdominal wall in the midline. With this maneuver described by Shehata, it is intended to determine if the testicle can be descended in a single surgical time (VILO technique), or if it will be a candidate for a serial elongation process, described by Shehata, with reintervention at 12 weeks post-surgery (See **figure 5(69) and 6**). Thus, it is not possible to randomize patients to determine which technique to perform, since if the patient's testicle is long enough, it would not make sense to perform Shehata's orchidopexy.

VILO group: Patients that the intra-abdominal testicle that reaches without any problem the contralateral internal inguinal orifice, and that, by means of a second laparoscopic clamp, this elevates the vascular pedicle and the deferens and can touch the anterior abdominal wall without difficulty (Figure 3), a primary descent will be performed, by creating a neotray, via the paravesical route, medial to the epigastric vessels, to directly descend the affected testicle towards the ipsilateral scrotum by means of a scrotal incision in the middle third.

Shehata group: Those testicles that, despite having performed a gentle and extensive mobilization of the intra-abdominal testicle, will attempt to lift the mesentery until it touches the abdominal wall. If the length is insufficient with this maneuver, we will perform a serial laparoscopic orchidopexy with preservation of testicular vessels, as described by Shehata (Figure 5 and Image 1). This involves contralateral fixation of the intra-abdominal testicle above the contralateral iliac crest by means of a vascular prolene point, preserving the testicular vessels and the vas deferens and its circulation. The laparoscopic wounds are closed, and the patient goes on to recovery.

Image 1.

Subsequently, it is programmed at 12 weeks, prior to abdominal Doppler USG, to document the testicular position and characteristics prior to the 2nd surgical time. During the second laparoscopy time, once the testicle is located, it is released from the fixation to the abdominal wall, and the final elongation of the vascular pedicle is documented with the same maneuver described by Shehata (image 2). The testicle is descended through an ipsilateral paravesical neotrayectum, until it is exteriorized through an incision in the middle third of the scrotum, fixing it with 2 prolene stitches to the scrotal tarsal.

Image 2.

Inguinoscrotal surgical time: The inguinoscrotal part in both techniques will be performed through a transverse incision in the middle third of the scrotum, for which, using a blunt laparoscopic dissector, the ipsilateral paravesical neo tract is created, suprapubic, exteriorizing the dissector through this same incision. The trajectory is extended until it allows testicular extraction/descent to the scrotum (image 3). The testicle will be measured in its longitudinal and transversal dimensions by means of a metallic ruler, in addition to photographically documenting the gonad, in search of malformations of the deferens.

Subsequently, each pole of the ipsilateral scrotal dartos will be punctured with simple vascular prolene stitches. Dartos closure with vicryl surgete 4 zeros, and skin with absorbable suture.

Image 3

Subsequently, the patient will go to recovery to be discharged to the floor for one night. The following day, outpatient management will be assessed.

Both groups will be monitored by means of a clinical review by the outpatient clinic one week after surgery and also at 3 and 6 months after surgery with a Doppler USG to visualize the irrigation and testicular volume and document the position of the affected testicle.

Shehata's group should have a post-surgical follow-up between 7-10 days after the first surgery and an appointment at 11 weeks for their preoperative evaluation of the 2nd surgical time.

For the Shehata group, if it is documented that the testicle "fell out of contralateral fixation" during the second laparoscopic intervention, the gonad will be re-fixed to complete its descent again 12 weeks later. This patient will be included in the final analysis.

Figure 7.

Postoperative management.

After the surgical procedure, patients will remain in recovery until showing anesthetic recovery, with mobilization of their extremities, normal vital signs, absence of pain, and tolerance to oral fluids by mouth.

Once the interventions are concluded, the patients will be sent home with a prescription with instructions with oral analgesics with Paracetamol (10mkdo) every 6hrs for the first day of surgery, followed by 3 days, with a schedule every 8hrs. Daily bath with soap and water, with wound cleansing. Written alarm data.

Those patients who do not present the minimum conditions for discharge will remain hospitalized for at least 24 hours for a new evaluation and possible discharge.

Follow-up:

1st consultation 7-10 days post-surgery: The healing of the laparoscopic and scrotal wounds will be assessed in those who have undergone scrotal orchidopexy.

2nd consultation 12-13 weeks post-surgery: Preliminary clinical results of post-surgical location will be evaluated, in addition to ruling out post-surgical complications, such as inguinal hernia, umbilical hernia, and testicular atrophy. An inguino-scrotal USG will also be performed, with determination of gonadal size and remeasurement of both inguinal orifices.

3rd consultation, 6 months after surgery: Clinical review, evaluation by USG Doppler with measurement of testicular volume, testicular dimensions, and presence of any wall defect.

4th consultation, 12 months after surgery: Clinical review, evaluation by USG Doppler with measurement of testicular volume, testicular dimensions, and presence of any wall defect.

Annual follow-up: color Doppler USG, with testicular measurements and clinical review.

Efficacy is considered if the corrected testicle remains in the lower or middle portion of the scrotum, and safety if it retains more than 75% of the initial volume calculated by USG, or if it retains its normal vascularity, or that, from direct measurements, at the time of descent into the scrotum. The testicles that lodge in high scrotal position, or higher, as well as those with a decrease in testicular volume of less than 75%, or with alterations in the color Doppler, will be considered failed corrections.

Ultrasonography measurements

Testicular Doppler USG will be performed preoperatively at 12-13 weeks post-surgery, prior to the 2nd surgical time, and 6 months after surgery. Paying attention to the determination of testicular size and volume, as well as testicular irrigation, in addition to the inguinal exploration to determine the characteristics of both internal inguinal orifices and the inguinal canal. This study will be performed by outpatient, through the radiology department.

10. Flowchart

Figure 8.

11. Sample size.

Exact – Proportion: Sign test (binomial test)

Analysis: A priori: For the estimation of a proportion of patients with non-palpable testicles, where a moderate effect of 0.3 is considered.

Input:	Tail(s)	=	Two
	Effect size g	=	0.3
	α err prob	=	0.05
	Power (1−β err prob)	=	0.80
Output:	Lower critical N	=	5.0000000
	Upper critical N	=	15.0000000
	Total sample size	=	20
	Actual power	=	0.8042080
	Actual α	=	0.0413895

A cutoff will also be performed when 16 patients are reached, and a post hoc analysis will be performed.

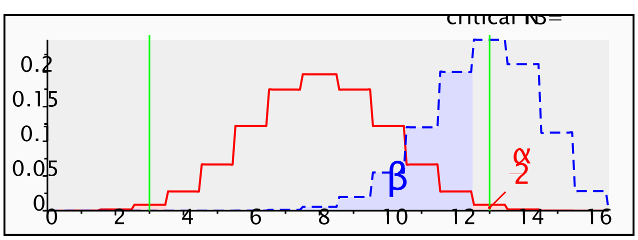
Exact – Proportion: Difference from constant (binomial test, one sample case)

Options: α balancing: α/2 on each side

Analysis: Post hoc: Compute achieved power

Input:	Tail(s)	=	Two
	Effect size g	=	0.3
	α err prob	=	0.05
	Total sample size	=	16
	Constant proportion	=	0.5
Output:	Lower critical N	=	3.0000000
	Upper critical N	=	13.0000000
	Power (1−β err prob)	=	0.5981346
	Actual α	=	0.0212708

With a Beta of 60%.



12. Definition of Variables.

Outcome variables

Objectives	Variable	Definition	Type of variable	Measuring scale	Number of measurements
Security	Testicular Atrophy	Loss of testicular volume >50% of the initial testicular volume or a postoperative testicular volume <25% compared to the volume of the contralateral testicle.(86)	Continuous numerical	Cubic millimeters	3
Efficiency	Anatomical success	Placement of the diseased testicle in the middle or lower third of the scrotum.	Dichotomous	Present Absent	1

13. Statistical Analysis.

STATISTICAL ANALYSIS

Descriptive statistics will be performed; continuous variables will be presented as arithmetic means and standard deviation for those with normal distribution or as medians or inter-quartile range for those without. The Shapiro-Wilk test will be used to evaluate the distribution of the data. To determine if there are statistical differences, the Xi2 test will be used for qualitative variables, and the Mann Whitney U test or Student's t-test for quantitative variables, depending on their distribution. In order to determine the differences between the baseline and final groups, Wilcoxon or paired t-tests will be used according to the distribution of the data.

A per-protocol analysis will be performed, considering only patients who have completed the study, and an intention-to-treat analysis, in which all patients will be included. For this analysis, those patients who discontinue follow-up or who do not have all the follow-up variables will be considered, and the baseline measurement will be taken into account as the final measurement.

According to the hypothesis, testicular atrophy in less than 5% was considered safe. The presence or absence of this will make it possible to obtain relative risk, relative risk reduction, absolute risk reduction, and finally, the number needed to be tartarized. The same can be obtained in the presence or absence of efficacy, measured by anatomical success.

A $p < 0.05$ will be taken as statistically significant.

Data will be analyzed using Stata 16.1 (College Station, Texas 77845 USA).

Ethical considerations.

This is a health research project involving human subjects. This protocol involves therapeutic efficacy and does not intend to modify any therapeutic indication. It is a quasi-experimental study in which a modification to a routine surgical procedure will be performed on subjects between 6 months and 7 years of age.

The activities to be carried out during the development of this research project are in accordance with the provisions of Title Two, Chapter III of the Regulations of the General Health Law on Health Research.

According to the risk classification, this protocol is considered greater than minimal risk for the patient. This is because, for research purposes, a procedure different from the conventional one will be performed in the surgical treatment of patients with intra-abdominal testicle in whom the testicular pedicle is not sufficient (it is not feasible to perform a primary descent). This procedure avoids the section of the testicular pedicle, as the conventional technique does. It is intended to reduce the frequency of testicular atrophy associated with conventional treatment.

The development of the project will adhere to the latest version of the World Medical Association Declaration of Helsinki (1964), updated in 2008 and to the ethical guidelines proposed in "International Ethical Guidelines for Health-Related Research Involving Human Subjects, Fourth Edition. Geneva: Council for International Organizations of Medical Sciences (CIOMS) 2016". Likewise, to the criteria for the execution of research projects for health-related research in humans established by the Ministry of Health in the Official Journal of the Federation, Norma Oficial Mexicana NOM-012-SSA3-2012.

The protocol will be submitted to the Instituto Nacional de Pediatría health research committees. It will begin once it has been approved.

Patients will be included following the informed consent process, which will be requested from parents or guardians and documented in the Informed Consent form. Children older than 8 years of age will not be included, so an informed consent process signed by the minor will not be included.

No blood samples will be obtained during the protocol. During visits 1, 2, and 3, a testicular ultrasound and a photograph of the scrotal area documenting the changes in the position of the testicle in the scrotum will be performed. In all cases, no photographs will be taken to identify the subject

Once approved by the institutional committees of both hospitals, the research protocol will be registered in the Clinical Trials electronic database (https://register.clinicaltrials.gov) in the experimental studies section.

The monitoring, implementation, performance, recording, analysis, and notification of possible eventualities will be in compliance with the Good Clinical Practices established by the International Conference on Harmonization.

The use and disposal of sensitive personal data of research subjects will be in accordance with the provisions of the Federal Law for the Protection of Personal Data in Possession of Individuals, in its articles 9, 11, 12, 13, 14, 15, 16, 19, 20 and 21. For this purpose, a Privacy Notice was prepared and will be documented for each research subject.

Public accountability for research will be conducted in accordance with Guideline 24: Public Accountability for Health-Related Research; proposed by the Council for International Organizations of Medical Sciences (CIOMS) 2016, to committees on research for health.

When submitting this protocol to the health research committees, the authors declare that they have no conflict of interest in the development, conduct, analysis of results, and dissemination of information. Should any conflict of interest arise during the protocol's development, it will be reported to the Research Ethics Committee and during the dissemination of the information.

The informed consent form was filled out according to the specifications provided by the National Institute of Pediatrics Research Ethics Committee.

15.- Biosafety

This research presents a biological risk level of 1, according to the WHO(87), which corresponds to "little or no individual and population risk."

For the purposes of this clinical trial, the acquisition of information or measurement of variables will not include the use of biological material, nucleic acids, CRETI reagents, or radioactive sources in evaluating the safety or efficacy of the interventions we perform.

The infectious biological waste generated as part of the clinical care of these subjects is handled in accordance with the stipulations of the clinical and laboratory areas set forth in the regulatory framework of the "FMS Facilities Management and Safety Plan" for the National Pediatrics Institute, which establishes the requirements for the separation, packaging, storage, collection, transportation, treatment and final disposal of infectious biological waste generated in these areas.

16.- Research resources.

Resources for this project will be obtained federally as follows:

A) Human resources:
   a. Outpatient: One surgical resident and one surgical attending physician, two nurses are required.
   b. Surgery: An anesthesiologist and an anesthesiology resident are required, as well as a pediatric surgeon and a resident in pediatric surgery, four nurses, two in the operating room, one in the reception area, and one in the recovery area.
   c. Radiology: One seconded Radiologist, one X-ray technician, and one X-ray resident.

B) Material Resources:
   a. Outpatient: We have an office with an examination table, desk, outpatient computer, and electronic medical record software. We also have a somatometry area for determining weight and height, with basic equipment (a scale for children under 10kg and a scale for preschoolers, schoolchildren, and adolescents).
   b. Ultrasound: We have an ultrasound diagnostic area with 2 ultrasound machines, a scanning table, and software for image review (PACS).
   c. Operating Room: We have a laparoscopy tower and 5mm instruments, as well as the necessary supplies.
   d. Hospitalization: The INP has surgical residents in all four grades of training (R1, R2, R3, R4, and chief resident), in addition to 24-hour nursing staff and orderlies.

C) Infrastructure: There is an operating room with all the necessary and indispensable elements for research.

17. Budget.

The costs were calculated based on the "Tabulador de cuotas de recuperación 2023", with SHCP authorization letter No. 349-B-273. Of which, we mention the following

Concept	Cost Level K
Consultation with folio	119 pesos
Opening of file	38 pesos
Pre-consultation	54 pesos
Subspecialist Consultation	1150 pesos
Abdominal Doppler ultrasound of 2 regions	2210 pesos
Anesthetic sedation	2868 pesos
General Anesthesia	6253 pesos
Orchidopexy Surgery	22,781 pesos

Thus, each patient will have a different cost, depending on the management technique used. Below, we present the cost, including the patients that will be invited to participate, and that once they are in the operating room, under anesthesia, it will be possible for several of these patients to have their testicles touched in the inguinal canal. The cost of their treatment is included.

Concept	Unit Cost Level K Weights	VILO	Shehata	Eliminated
Consultation with folio	119 pesos	119	119	119
Opening of file	38 pesos	38	38	38
Pre-consultation	54 pesos	54	54	54
Subspecialist Consultation	1,150 pesos	4,600	8,050	4,600
Abdominal Doppler ultrasound of 2 regions	2,210 pesos	6,630	6,630	4420
Anesthetic sedation	2,868	0	0	0
General Anesthesia	6,253 pesos	6,253	12,506	6253
Orchidopexy Surgery	22,781 pesos	22,781	45,562	22,781
Total		**40475**	**72959**	**38,265**

We consider that 30 patients will need to be recruited, estimating that approximately 20% during sedation may be palpated in the inguinal region in addition to possible leakage. However, these patients will continue with general anesthesia at that time for the correction of their cryptorchidism openly via the inguinal route. However, for the analysis, these patients will be excluded.

Of the remaining 20 patients, we consider that approximately half of the patients will require treatment according to Shehata, and the rest will be amenable to treatment with the VILO technique, so the costs are as follows.

Technique	Individual cost	Including	Total cost
VILO	40,475	10	404,750
Shehata	72,959	10	729,590
Removed (Inguinal)	38,265	10	382,650
Total cost:			**1,516,990**

This gives **a total cost of 1,516,990 pesos.**

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