

# Modified percutaneous internal ring suture technique for inguinal hernia repair in girls, can it be even better?

Original  
Article

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## ABSTRACT

**Introduction:** The percutaneous internal ring suturing technique is known for its simplicity and superior cosmetic outcomes. Alternatively, induced peritoneal injury as in the Godoy Burnia technique involves the use of instruments to invert and cauterize the hernial sac. We present a novel approach that integrates the strengths of both techniques, offering a time-efficient and reliable method with low recurrence rates while maintaining excellent cosmetic results.

**Patients and Methods:** This is a retrospective analysis of laparoscopic inguinal hernia in female patients using the modified percutaneous internal ring suturing technique. Patients' records were analyzed for operative time, complications, recurrence, and cosmetic outcome. In all patients, 18-gauge venipuncture needles were manually modified into a J-shaped curved tip allowing percutaneous introduction of a nonabsorbable 2/0 suture encircling the internal ring followed by cauterization of the sac at the level of internal ring using sealed 18-gauge cannula under laparoscopic visualization without instruments.

**Results:** Fifty-eight female patients with ages ranging from 1 to 11 years (average 2.8 years) operated over 8-year-period (2016–2023). The average operative time for the 42 unilateral cases was (11.8 min), while for the 16 bilateral cases was (20.4 min). All patients were followed-up for at least 6 months. No recurrences or stitch sinuses were noted, however two patients complained from a palpable subcutaneous suture, and 5 cases had minimal retro-peritoneal hematoma. All parents were satisfied with the cosmetic results.

**Conclusion:** The combination of cauterization of the hernial sac with percutaneous internal ring ligation under laparoscopic visualization is an effective, reproducible, and safe technique. It demonstrates high reliability, excellent cosmetic outcomes, and no increased risk of recurrences.

**Key Words:** Female hernia, inguinal hernia, laparoscopic hernia, percutaneous internal ring suture.

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## INTRODUCTION

Inguinal hernia is one of the most common congenital malformations presenting in childhood. In ~1000 newborns, there is 66 male cases and about eight females. Notably, females are more likely to present with bilateral inguinal hernia compared with males (25.4 vs. 12.9%,  $P < 0.01$ )<sup>[1]</sup>. Many centers now routinely employ laparoscopic techniques for hernia repair in pediatric patients, with numerous reports detailing various laparoscopic approaches<sup>[2]</sup>. The reported advantages of laparoscopic repair include excellent visual exposure, minimal dissection, reduced complications, comparable recurrence rates, and enhanced cosmetic outcomes compared with the traditional open approach<sup>[3]</sup>. Laparoscopic techniques can be categorized into two primary subgroups based on the suturing method: intracorporeal and extracorporeal suturing. Among the extracorporeal techniques, the

percutaneous internal ring suturing (PIRS) technique is particularly distinguished<sup>[4-6]</sup>. Recurrence rates following PIRS vary widely, ranging from 0 to 18.6%<sup>[4,6,7]</sup>. This could be attributed to several factors, with suture loosening being a significant concern. Critics of the PIRS technique argue that complete disconnection of the hernial sac at the internal ring is more critical than merely suturing the ring<sup>[8]</sup>.

The induction of peritoneal injury using electrocautery has been experimentally shown to result in a stronger and more durable obliteration of the inguinal ring<sup>[9]</sup>. A noteworthy alternative technique is the Burnia technique, which involves the use of an additional working port to grasp, twist, and cauterize the hernial sac using low-current monopolar electrocautery<sup>[10]</sup>. Reported recurrence rates for this technique range from 0 to 7.7%<sup>[11-13]</sup>. In this study, we propose a modification of the PIRS technique that integrates key elements from both approaches, aiming

to provide a reliable, time-efficient method with minimal recurrence rates while preserving cosmetic outcomes.

### **PATIENTS AND METHODS:**

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This study presents a retrospective analysis of laparoscopic inguinal hernia repairs in female patients using the modified PIRS technique, covering the period from January 2016, when this approach was first developed, to December 2023. Patient records were reviewed for key outcomes, including operative time, complications, recurrence rates, and cosmetic results. In this technique, 18-gauge venipuncture needles were manually modified to create a J-shaped curved tip, enabling the percutaneous introduction of a non-absorbable 2/0 suture to encircle the internal ring. This was followed by cauterization of the hernial sac at the internal ring using a sealed 18-gauge cannula under laparoscopic visualization, without the need for additional instruments. The study included only female patients, focusing on cases of bilateral congenital inguinal hernia (CIH), unilateral CIH with a questionable contralateral side, and CIH associated with umbilical hernia, all of which were repaired laparoscopically using the modified technique. Patients with recurrent hernias, and complicated cases such as sliding or incarcerated hernias, were excluded from the study. An Institutional review board approval was obtained.

### **Statistical analysis**

Statistical analysis was performed using computer software the statistical package for social studies (SPSS: IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) Quantitative data was expressed as mean±standard deviation (SD) or median and range as appropriate. Qualitative data was expressed as frequency and percentage. Independent sample t test and Mann–Whitney U tests were used for comparison. Pearson test of correlation was used to detect correlation between study variables. The difference was considered significant at *P* less than or equal to 0.05.

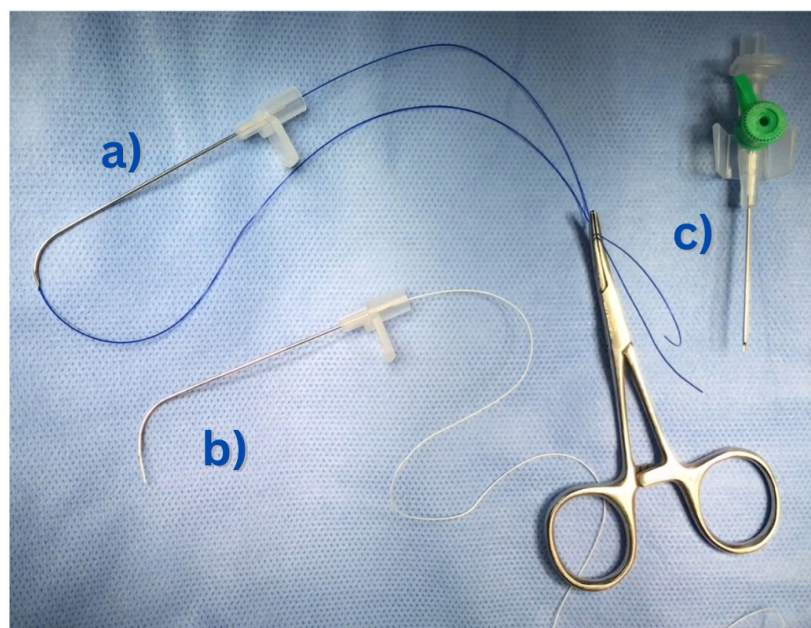
### **Operative technique**

The fundamental principle of the technique involves the cerclage of the internal ring using nonabsorbable sutures, followed by surface cauterization of the peritoneal lining. Under general anesthesia, the patient is placed in a supine position with the monitor positioned at the foot of the bed. The surgeons stand on either side of the patient's upper body, with the main surgeon's position determined by their dominant hand rather than the side of the hernia. We have observed that it is advantageous for the surgeon's dominant hand to be closer to the patient's lower body; for example, right-handed surgeons may find it more effective to stand on the patient's right side. It is crucial to evacuate the bladder,

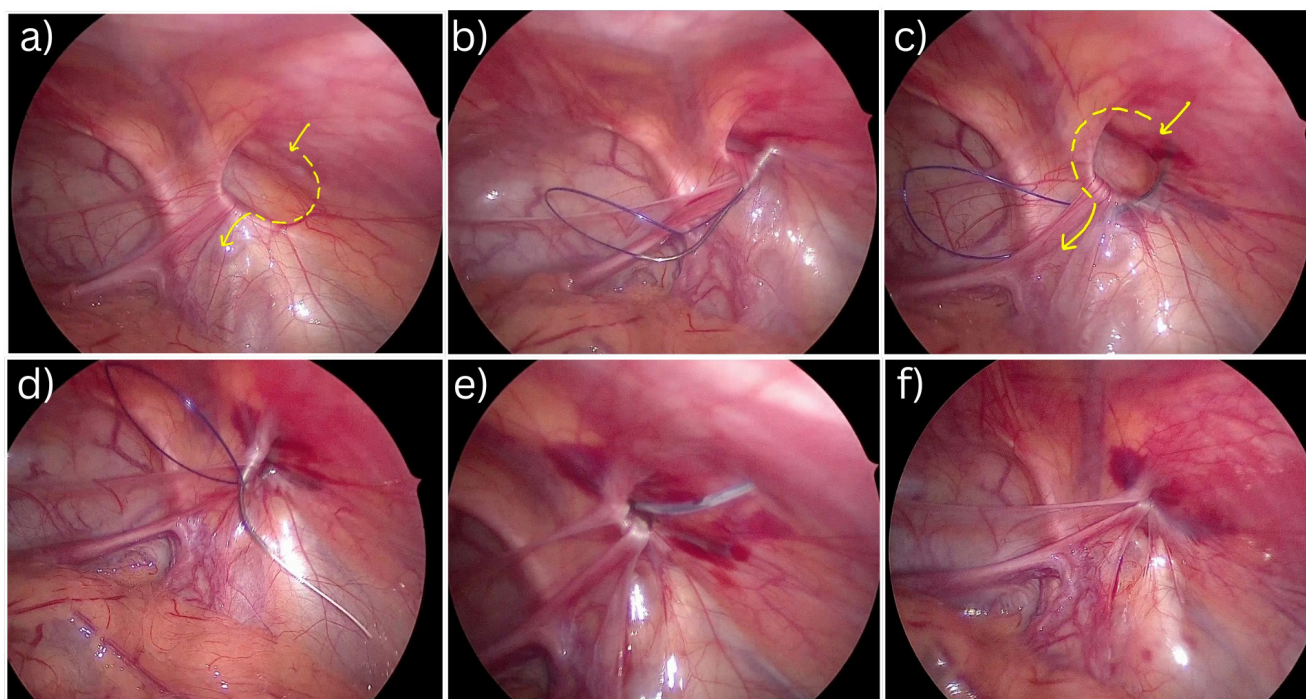
either through the Credé maneuver or by instructing older patients to empty their bladder before the procedure. A single 5 mm port is utilized through the umbilicus for laparoscopic visualization. The needles employed are venipuncture needles, which are carefully bent to create a gentle curve approximately 15 mm from the needle tip. The author typically uses a larger needle driver to fashion the tip into a J-shaped configuration, with the tip angled at 100° to the needle shaft (Fig. 1). Two curved needles are required for the procedure: one is a retrieval needle containing a 2–0 monofilament polypropylene (Prolene) suture, and the other is a suture needle threaded with 2–0 braided nonabsorbable sutures (Ethibond). A third needle, along with its plastic cannula bent at the mid-shaft, is used as a diathermy tip (Fig. 1).

The procedure begins with a 2 mm snip over the internal inguinal ring, made under laparoscopic guidance using an 11-blade scalpel. The retrieval needle is first advanced vertically until it is visualized beneath the peritoneum at the 12 o'clock position. The needle is then maneuvered to encircle 180° of the internal ring just beneath the peritoneum, exiting at the 6 o'clock position. At this point, the Prolene loop is introduced into the abdominal cavity, allowing the formation of a self-opening suture loop after needle withdrawal. Next, the suture needle is introduced through the same skin incision, similarly advanced vertically until its tip appears at the 12 o'clock position under the peritoneum. The needle is then guided to encircle the remaining 180° of the internal ring, following the same pathway until it reaches the exit point of the retrieval loop. The round ligament of the uterus is included in the suture to enhance the strength of the repair. The needle tip is carefully manipulated through the loop, which is then retracted to tighten around the needle tip. The suture is pushed through the needle for 2–3 cm, after which the needle is withdrawn, leaving the suture encircled by the retrieval loop. The loop is then gently withdrawn, externalizing the suture. At this stage, both ends of the suture project through the small skin puncture, fully encircling the internal ring.

Subsequently, the third cannula, fitted over a needle, is introduced ~1.5–2 cm cephalad to the internal ring. This is used to apply monopolar spray diathermy to the peritoneal surface of the internal ring, distal to the suture. The cauterization is directed to the inner aspect of the ring, avoiding the abdominal side. A low current is used, sufficient to induce peritoneal injury and coagulation without breaching the peritoneal surface. Finally, the suture is externally tightened to close the ring completely. Care is taken not to excessively tighten the knot to avoid cutting through the tissue. A small subcutaneous pouch is bluntly created beneath the skin puncture to allow the suture ends to fall deep, reducing the risk of developing a stitch sinus (Fig. 2).



**Fig. 1:** The needles used for the ligation and cautery: a) Retrieval needle with a 2/0 monofilament suture is passed through and tied on a hemostat b) Suture needle with a non-absorbable 2/0 braided suture just projecting through its tip c) an IV cannula over needle used for cautery.



**Fig. 2:** Technical steps: a) the retrieval needle is introduced to encircle half the circumference of the internal inguinal ring (yellow dotted line and arrow) b) The retrieval loop is advanced for an adequate length into the abdomen c) The suture needle is introduced to encircle the opposite half of the circumference (yellow dotted line and arrow) d) The tip of the needle is guided through the retrieval loop and the ligation suture is advanced into the abdominal cavity through the loop e) spray diathermy is applied to the inner aspect of the internal ring using the tip of the very puncture needle f) the suture is tightened to completely obliterate the intern internal ring.

**RESULTS:**

The study included only female patients who underwent laparoscopic surgery for clinically evident indirect inguinal hernia using the modified technique. The surgeries were conducted from January 2016 to December 2023. A total of 58 patients were included, with a mean age of  $3.66 \pm 2$  years (range: 1–11 years). Among these, 42 had unilateral hernias (25 right-sided and 17 left-sided) and 16 had bilateral hernias (Table 1). The mean operative time for unilateral cases was  $11.76 \pm 2.3$  min (range: 8–19 min), while for bilateral cases, it was  $20.37 \pm 4.9$  min (range: 15–30 min). This difference was found to be statistically significant.

An incidental finding of a contralateral patent processus vaginalis (PPV) was detected in 7 cases. In these cases, only the inner aspect of the internal ring was cauterized without ligation. Subperitoneal hematomas were observed in five patients, all of which were self-limited and did not affect the postoperative course (Fig. 3). Careful review of the operative videos confirmed that no major vessels were injured or transected by the needles. Minor bleeding at the cautery cannula puncture site was noted in 12 patients. Operative time was not significantly prolonged in the

subgroup with complications (bleeding and hematoma) (Table 1).

All patients were routinely followed-up for at least 6 months, except for the last four patients, who were followed for 3 months. No recurrences were detected in any of the patients. Additionally, no patients reported developing a metachronous hernia on the contralateral side during follow-up. No cases of stitch sinus were detected; however, two patients reported palpable subcutaneous sutures. One patient expressed concern about the persistence of the hernial sac, which gave her a sense of fullness in the pubic region. Seven patients had a visible skin mark.

Parental satisfaction was assessed in 48 patients, with scores ranging from 7 to 10 and a mean of  $9.43 \pm 0.8$  (Fig. 4). Although the mean satisfaction score was slightly higher in the 42 cases without complications (both intraoperative and postoperative), the difference was not statistically significant when compared with those with complications (9.5 vs. 9). Correlation analyses revealed no significant association between operative time and intraoperative bleeding or patient age. However, bilaterality was positively correlated with operative time. Parental satisfaction showed no significant correlation with age, hernia side, or the presence of complications (Table 2).

**Table 1:** Patients data, operative data, and outcome

	Number (Percentage)	P value
Age	$3.66 \pm 2$	
Side		
Unilateral	42/58 (72.4)	
Right	25 (43.1)	
Left	17 (29.3)	
Bilateral	16/58 (27.6)	
PPV	7/58 (12)	
Operative Time		
Unilateral	$11.76 \pm 2.3$	0.000*
Bilateral	$20.37 \pm 4.9$	
Operative complications		
Bleeding	12 (20.6)	0.373
Hematoma	5 (0.08)	
Outcome		
Recurrence	0	
Palpable Stitch	2 (0.03)	
Palpable Sac	1 (0.02)	
Skin Mark	7 (0.12)	
Satisfaction		0.152
Overall	9.44	
Without complications	9.5	
With complications	9	

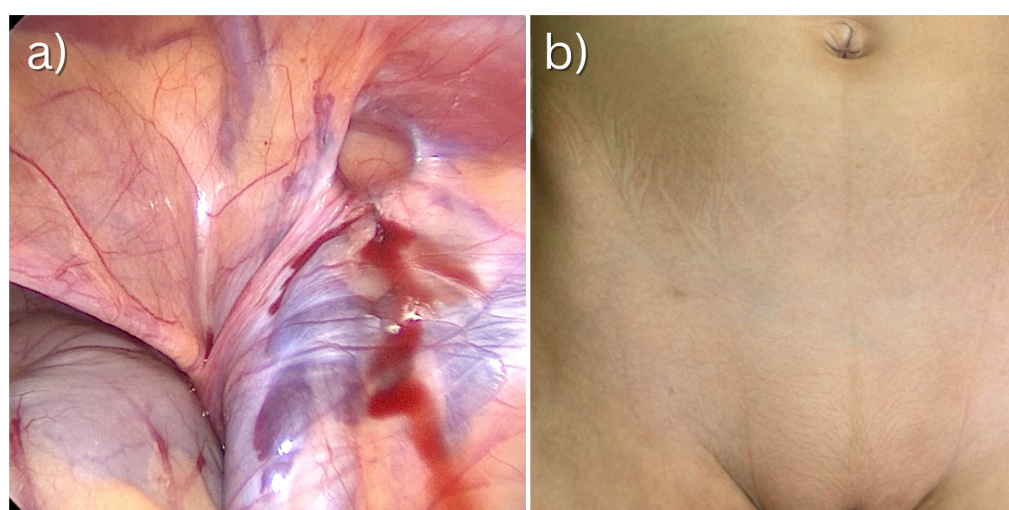
Using Independent sample t test used to compare means.  
 \*\*Is significant when P value is less than 0.005.

**Table 2:** Correlations between study variables

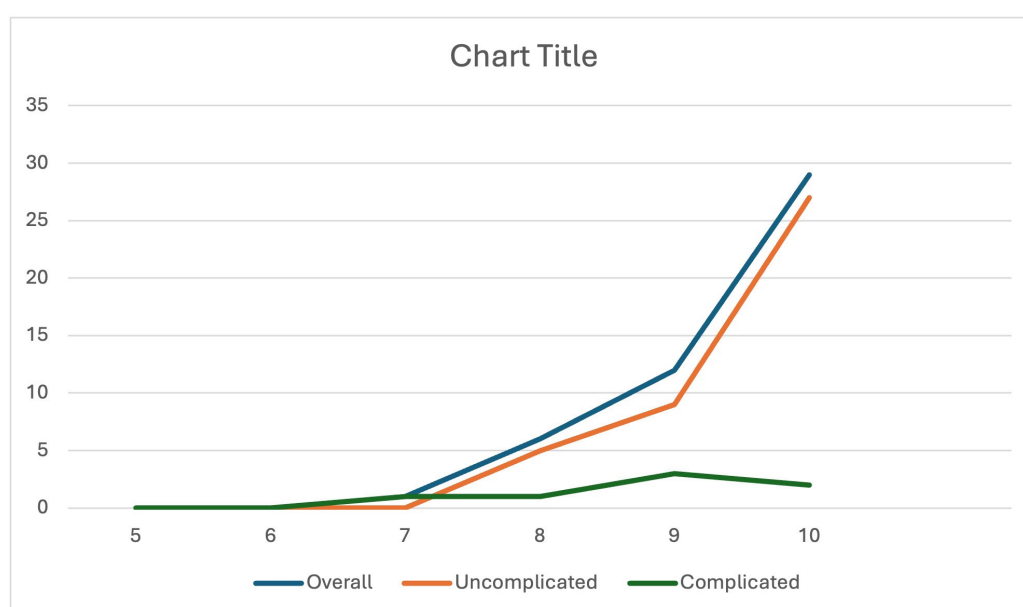
Variables	Correlation coefficient	P value
Operative Time		
Age	0.076	0.076
Bleeding	-0.127	0.343
Bilaterality	0.665**	<0.001
Satisfaction		
Age	-0.029	0.846
Bilaterality	0.065	0.659
Complications	0.210	0.152

Using Spearman test for correlation.

\*\*Is significant when P value is less than 0.005.



**Fig. 3:** Examples of operative and postoperative complications: a) Retroperitoneal minor hematoma and intra-peritoneal bleeding b) Visible skin mark at the suture site.



**Fig. 4:** Parents' satisfaction about the cosmetic appearance relative to postoperative complications: Parents' satisfaction according to complications on a scale from 1 to 10. The overall scores (blue line) are compared with the subgroups of patients with (green line) and without (orange line) complications.

## DISCUSSION

Since the introduction of laparoscopic inguinal hernia repair into pediatric surgery, the field has seen continuous evolution with a plethora of techniques and modifications. Despite this, the laparoscopic approach initially lagged in popularity, largely due to the satisfactory outcomes of open surgery and the absence of a well-established laparoscopic technique that could offer equivalent results<sup>[14]</sup>. This gap led to an influx of modifications and techniques, each aiming to achieve optimal repair<sup>[15]</sup>. The exploration of various laparoscopic and percutaneous techniques, and their combinations, has been a significant focus in the quest for an ideal approach. In this study, we evaluate a combination of two established innovations: the PIRS technique, enhanced with electrosurgical intervention, utilizing only venipuncture needles for increased strength and durability.

The concept of extracorporeal percutaneous suturing of the internal ring was introduced in 2003 by Prasad *et al.*, following the pioneering work of Yeung in laparoscopic herniorrhaphy<sup>[16]</sup>. This innovation was preceded by the development of specially designed needles for extracorporeal suturing, assisted by a single micro-laparoscopic clamp<sup>[2,17]</sup>. These early efforts paved the way for a surge of various percutaneous techniques<sup>[8-16,18]</sup>. In 2006, Patkowski *et al.* introduced a simple and elegant technique of PIRS, using a laparoscope to guide a non-absorbable suture through the barrel of an 18-gauge injection needle, which was manipulated percutaneously to encircle the internal ring. The knot was then tightened externally and buried in the subcutaneous space<sup>[4]</sup>.

The primary advantage of this technique is that it eliminates the need for technically demanding and time-consuming intracorporeal suturing, while also minimizing the risk of visceral injury due to the lack of instrument manipulation within the abdominal cavity. This method simplifies and expedites the closure of the internal ring, making it accessible even to surgeons with basic skills in minimally invasive surgery. As a result, it may encourage the broader adoption of minimally invasive techniques in pediatric inguinal hernia repair, along with all their associated benefits. Additionally, in resource-limited settings, this approach is considered cost-effective and economically viable<sup>[4,19]</sup>. At our center, we have experimented with and refined various versions of percutaneous techniques since 2014, including the use of spinal needles, venipuncture needles of different sizes, the addition of instruments, and comparisons between intra-abdominal and subcutaneous knot placement.

The age of the patients in this study ranged from 1 to 11 years, with a mean of  $3.6 \pm 2$  years. At our institution, the preferred procedure for infant girls is open repair. The exclusion of girls under one year of age from this study was based on literature describing a higher incidence of hernia incarceration and a significantly increased rate of sliding hernia (45.8%) in patients under one year of age, compared with 14.9% in older children<sup>[20]</sup>. Additionally, studies indicate that the highest incidence of inguinal hernia in girls occurs between the ages of 1 and 5 years, with a peak before the age of 10 years<sup>[21,22]</sup>.

The PIRS technique relies on various percutaneous tools to encircle the internal ring and pass the suture. Different needles have been employed over the years: Prasad *et al.* (2003) used a steel awl, Shalaby *et al.* (2006) utilized a Riverdin needle, Patkowski *et al.* (2006) applied an 18-gauge needle, while others used specially designed needles<sup>[2,4,16,17,23]</sup>. The 18-gauge needle, with an outer diameter of 1.27 mm, has a smaller skin puncture. Additionally, this needle can be manually curved to various degrees to accommodate different ring morphologies, unlike other needles that have a fixed curve. It also allows the insertion of 2/0 or 3/0 sutures with ease. Importantly, the same gauge needle, with its cover sheath as an insulator, can be safely used percutaneously for cauterizing the peritoneum.

To minimize the incidence of recurrence, the concept of peritoneal injury has been explored. Blatnik *et al.* conducted an animal study evaluating the impact of adding minor peritoneal trauma during laparoscopic repair<sup>[9]</sup>. They suggested that the repair may rely heavily on the suture to prevent recurrence, and in cases of suture failure, the recurrence rate could increase. Inflicting minor peritoneal trauma may induce sufficient scarring to provide a more durable repair, imitating the original technique of high ligation and division of the sac, where the raw peritoneal surface induced a dense fibrotic reaction that resulted in a tight and durable closure of the ring. In this study, we evaluated the combined benefits of the cosmetically favorable and straightforward PIRS technique with the concept of peritoneal cauterization. A similar approach, known as the Burnia Repair, also utilizes minimal peritoneal injury to reduce recurrence by inducing a scarring reaction<sup>[9,24]</sup>. In our series, we employed monopolar diathermy in spray mode to inflict minimal and superficial peritoneal injury. This technique allows surface coagulation of the peritoneum without causing deep tissue injury, which theoretically reduces the risk of suture cut-through. This modification was applied exclusively to female patients due to the unique anatomical characteristic of the absence of vital structures at the internal ring, unlike in males, where the vas deferens and testicular vessels

are present, potentially affecting fertility. The efficacy of this approach was reflected in our outcomes, with no recurrences observed during the follow-up period, which ranged from 3 months to eight years.

One of the significant advantages of laparoscopic repair is its short operative time, which is comparable to that of the open technique, particularly in bilateral hernias. In the current study, the operative time for unilateral cases averaged  $11.76 \pm 2.3$  min, while bilateral cases averaged  $20.37 \pm 4.9$  min. Patkowski *et al.* reported an average operative time of 19 min for unilateral and 24 min for bilateral hernias<sup>[4]</sup>. Similarly, Thomas *et al.* reported 14.3 min for unilateral and 20.4 min for bilateral procedures<sup>[25]</sup>. However, a longer operative time was reported by Wolak *et al.* with a mean duration of approximately 26 and 32 min<sup>[6]</sup>. This suggests that our study's modification does not add extra time to the procedure compared with published results. Overall, studies comparing the operative times of percutaneous techniques to laparoscopic techniques generally show shorter operative times for both unilateral and bilateral cases, although the difference is not statistically significant<sup>[26]</sup>.

Despite the simplicity and efficiency of the PIRS technique, Patkowski *et al.* reported a recurrence rate of 2.8%, detected within the first 4 months postoperatively<sup>[4]</sup>. All recurrences occurred in boys over 1.5 years of age, and re-operations revealed no suture in place, suggesting a technical error. Other studies have similarly reported low recurrence rates after the PIRS technique, ranging from 0% to 3.3%<sup>[6,25,27–29]</sup>. However, Kilda *et al.* reported a significantly higher recurrence rate after PIRS (18.57%) compared with 4.11% after laparoscopic intracorporeal closure of the processus vaginalis<sup>[7]</sup>. Interestingly, they found no sex-related difference in recurrence rates, contrasting with Patkowski *et al.*'s findings<sup>[4]</sup>. Kilda *et al.* also proposed that the cause of recurrence is primarily technical rather than related to the learning curve, although Thomas *et al.* suggested that the recurrence rate decreased after surgeons had treated 50–75 patients, particularly in children over one year of age<sup>[25]</sup>. Wolak *et al.* reported a 2.4 times higher recurrence rate after the PIRS procedure compared with open repair, although this difference was not statistically significant<sup>[6]</sup>. In our series, no recurrences were encountered. This suggests that incorporating this additional step in the repair may enhance the already high success rate, potentially elevating the outcome to an even higher level.

The initial motivation for introducing laparoscopy into the field of pediatric inguinal hernia repair was to address the debate over contralateral exploration during unilateral hernia surgery. Approximately 41% of children with unilateral hernia are found to have a PPV. This condition is more common in boys, is

more frequently observed on the right side, and is seen more often in children over the age of 3. The reported incidence of developing a metachronous hernia ranges from 5.8% to 11.6%<sup>[30]</sup>. In our study, 12% of the cases exhibited a contralateral PPV, which was asymptomatic. Notably, the use of surface cautery in our approach proved effective, as no metachronous hernias were observed during follow-up.

The proximity of the internal inguinal ring to vascular structures, including the inferior epigastric vessels, iliac vessels, and testicular arteries in males, poses a significant risk of vascular injury. In our study, subperitoneal hematomas were identified in 5 patients, and minor intraperitoneal bleeding was noted in 12 patients; all instances were self-limited and did not impact the postoperative course. A thorough review of the operative videos confirmed that no major vessels were injured or transfixated by the needles. Previous reports have noted incidental punctures of the iliac vein, which were managed with gentle external pressure<sup>[4,25,27]</sup>. Vascular injuries typically occur during the insertion of the first suture thread; thus, it is crucial to ensure that the needle tip is visualized before advancing further<sup>[31]</sup>. While no major vascular injuries requiring conversion were reported, meticulous attention during needle manipulation around the internal ring is essential to prevent bleeding, which can obscure the field, impair vision, and prolong operative time.

A major criticism of the PIRS technique is the persistence of the distal sac. Some studies have addressed this by using obliterating adhesive tape to close the sac<sup>[29,32]</sup>. Proponents of the technique argue that, in many laparoscopic repairs, the distal sac is either left intact or disconnected at the internal ring level, with comparable recurrence and hydrocele rates<sup>[19]</sup>. In our study of 58 cases, only one patient reported a palpable sac sensation in the groin, which gradually resolved during follow-up.

Despite the cosmetic advantages of the PIRS technique, there have been reports of skin incision and umbilical port complications<sup>[25,29]</sup>. However, multiple studies have documented no significant skin complications with the PIRS technique<sup>[7,33,34]</sup>. In our study, no notable skin puncture-related complications were observed, although 12% of the parents noticed a visible puncture mark. Compared with open hernia repair and traditional laparoscopic techniques, PIRS and modified PIRS techniques generally offer better cosmetic results<sup>[7,27,33,34]</sup>. A study assessing pediatric hernia repair outcomes at a national level in Lithuania found that PIRS was significantly more cosmetically favorable than traditional techniques, with none of the parents in the PIRS group finding the skin mark detrimental to the expected aesthetic outcome<sup>[35]</sup>. In

our study, the overall parental satisfaction was high, with a mean score of 9.5/10, attributed to the absence of recurrences and superior cosmetic results.

Although the results are promising, the new modification of the PIRS technique, tentatively named ‘Bovie-PIRS,’ requires further evaluation in a randomized controlled trial to provide more robust evidence of its efficacy and recurrence rate with a larger sample size.

## CONCLUSION

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The combination of cauterization of the hernial sac with percutaneous internal ring ligation under laparoscopic visualization is an effective, reproducible, and safe technique. It demonstrates high reliability, excellent cosmetic outcomes, and no increased risk of recurrences.

## ABBREVIATIONS

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**PIH**, Pediatric inguinal hernia; **PIRS**, Percutaneous internal ring suture; **PPV**, patent processus vaginalis.

## CONFLICT OF INTEREST

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There are no conflicts of interest.

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