Clinical Study

Laparoscopic Hernia Repair versus Open Herniotomy in Children: A Controlled Randomized Study

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1. Introduction

Inguinal hernia (IH) repair is one of the most frequently performed surgical procedures in infants and children. Open herniotomy is its standard treatment against which all alternative modalities of treatment are evaluated. It is credited with being easy to perform, having a high success rate, and low rate of complications. However, recently, many centers routinely perform laparoscopic hernia repair in children and there have been numerous reports describing various laparoscopic techniques rather than the traditional open approach [1–4].

Reported advantages of laparoscopic hernia repair include excellent visual exposure, minimal dissection, less complications, comparable recurrence rates, and improved cosmetic results compared with the traditional open approach. In addition, laparoscopic hernia repair also allows contralateral patent process vaginalis (PPV) hernias to be defined and repaired in the same operation [5–7].

Randomized control study of laparoscopic hernia repair versus OH in pediatrics is rare in the literature [8–10]. This paper presents a big series and describes a new technique which is the use of Reverdin Needle (RN) in laparoscopic hernia repair in comparison with OH, to the best of our knowledge, this technique has not been reported before. So, this prospective randomized controlled study was conducted to compare laparoscopic assisted hernia repair by RN with OH in infancy and childhood as regards operative time, hospital stay, postoperative hydrocele formation, recurrence rate, iatrogenic ascent of the testis, testicular atrophy, and cosmetic results.

2. Patients and Methods

A prospective randomized controlled study was carried out in the Pediatric Surgery Unit of Al-Azhar University Hospitals and 2 private hospitals, over four-year period.
Table 1: The demographic data for the two groups.

| Groups                      | Group A |          | Group B |          | Total   | P value |
|-----------------------------|---------|----------|---------|----------|---------|---------|
|                             | Number  | %        | Number  | %        |         |         |
| Sex                         |         |          |         |          |         |         |
| (i) Male                    | 38      | 30.4     | 92      | 73.6     | 179     | (71.6%) | 0.48**  |
| (ii) Female                 | 87      | 69.6     | 33      | 26.4     | 71      | (28.4%) |         |
| Age/month                   |         |          |         |          |         |         |
| (i) 1–12                    | 58      | 46.4     | 50      | 40       | 95      | (38%)   | 0.80**  |
| (ii) 12–24                  | 45      | 36       | 55      | 44       | 113     | (45.2%) |         |
| (iii) 24<                   | 22      | 17.6     | 20      | 16       | 42      | (16.8%) |         |
| Presentation                |         |          |         |          |         |         |
| (i) Unilateral in obese child | 25    | 20       | 28      | 22.4     | 53      | (21.2%) |         |
| (ii) Bilateral              | 44      | 35.2     | 48      | 38.4     | 52      | (20.8%) |         |
| (iii) Recurrent inguinal hernia | 12    | 9.6      | 15      | 12       | 27      | (10.8%) | 0.18**  |
| (iv) Inguinal hernia with umbilical hernia | 18    | 14.4     | 22      | 17.6     | 40      | (16%)   |         |
| (v) Inguinal hernia with questionable other side | 26    | 20.8     | 12      | 9.6      | 38      | (15.2%) |         |

**Insignificant.

Figure 1: Reverdin needle.

The study was approved by our ethical committee. Two hundred and fifty patients with IH were randomized into two equal groups by a random-number table sequence after a written informed parental consent was obtained. Group A (n = 125) was subjected to laparoscopic assisted inguinal hernia repair by RN (Figure 1) (Martin Medizin Technik, Tuttlingen, Germany). Group B (n = 125) was subjected to open herniotomy (OH). The demographic data were matched between both groups (Table 1). Inclusion criteria included bilateral inguinal hernia, recurrent hernia, hernia in obese child, inguinal hernia with umbilical hernia and hernia on ipsilateral with questionable contralateral side. Exclusion criteria included unilateral inguinal hernia in nonobese child and hernia with undescended testicles. The main outcome measurements were operative time, hospital stay, postoperative hydrocele formation, recurrence rate, iatrogenic ascent of the testis, testicular atrophy, and cosmetic results. All children were subjected to full history taking, thorough clinical examination, routine laboratory investigations, and inguinocrotal U/S. Testicular size and perfusion of male cases (n = 179) were evaluated in the preoperative, early postoperative (within 48 hours of surgery), and late postoperative periods (6 months after surgery) using Gray-scale ultrasonography, and Doppler ultrasound (DUS) (both duplex and power Doppler mode). (Sonoline Antaris, Siemens, Medical Corporation U/S Erlangen, Germany). The patients were examined with a 7.5 MHz linear, phased-array transducer. Both testes were scanned in transverse and longitudinal planes while the patient was in the supine position, and sedation was used when required in the form of paracetamol suppository. The testis on the unaffected side (in unilateral cases) was scanned first to optimize the Doppler settings for assessment of slow blood flow in the testis.

The volume of testis on both sides was calculated using the ellipsoid formula (volume = \(0.523 \times D_1 \times D_2 \times D_3\)), where \(D_1\), \(D_2\), and \(D_3\) were the maximally measured longitudinal, anteroposterior, and transverse diameters.

The ratio \(v\) was defined as \(v = \text{testicular volume of the operated side (postoperatively)} / \text{testicular volume of the same side (preoperatively)}\). Volume of the testis and the ratio \(v\) were calculated during the preoperative and late postoperative examinations.

Criteria of testicular atrophy were defined as 75% reduction in estimated testicular volume, ratio \(v\) less than 75%, and resistive index (RI) more than 0.7.

All operations were done by the first three authors, and a senior resident holds the camera. In group A, after induction of general endotracheal tube anesthesia, the patient was placed supine in Trendelenburg’s position. Insertion of the main umbilical port was accomplished by the open method. Pneumoperitoneum was established to a pressure of 8 to 12 mm Hg.

Laparoscopy was used for initial visualization of the pelvis and IIRs on both sides. Laparoscopic hernia repair was done according to the technique described by Shalaby et al., 2006, with some modifications [11]. A 3 mm Maryland...
after 7 days, 2 weeks, 6 months, 1 year, and 2 years. Parents
wound was closed in layers, using absorbable suture.

The 4/0, 3/0 absorbable (Monocryl) suture. The distal sac was
slit open to prevent postoperative hydrocele formation. The
skin incisions were closed with Steri-strips.

Table 2: Distribution of the studied groups according to operative time.

| Groups                        | Group A (mean SD) | Group B (mean SD) | P value |
|-------------------------------|------------------|------------------|---------|
| Unilateral and recurrent unilateral | 7.6 ± 3.5 minutes | 12.8 ± 4.5 minutes | <0.001* |
| Hernia in obese child         | 9.2 ± 4.6 minutes | 14.3 ± 3.6 minutes | <0.001* |
| Bilateral                     | 11.4 ± 2.7 minutes | 21.9 ± 7.2 minutes | <0.001* |

*Significant.

Figure 2: Insertion of RN on the right side.

forceps, holding the tip of a 3/0 Prolene thread, was inserted
into the abdomen without trocar at the lateral border of the
rectus muscle just above the level of the umbilicus leaving the
long end of the thread outside the abdomen (Figure 2).

A stab incision of the skin was done 2 cm above and
lateral to the IIR on the right side, and 2 cm above and medial
to the IIR on the left side and RN was inserted into the
abdominal cavity (Figure 2). The needle was manipulated
to pierce the peritoneum at 3 O’clock on IIR and was
advanced to pass through the lower margin of IIR under the
peritoneum and in front of the spermatic vessels and vas to
pierce the peritoneum at 9 O’clock on the IIR. Care was taken
to avoid injury of the spermatic vessels, and vas by grasping
and lifting the peritoneum away from the vas and vessels
and the RN was seen all the time beneath the peritoneum (needle
sign). Then, the side of the hole of RN was opened and the
thread hold by Maryland was inserted inside it. Then, the side
of the hole of RN was closed, and the needle was withdrawn
backward in the same path till reaching the starting point at
3 O’clock. Then, RN mounted by the thread was reinserted
again at 3 O’clock and was advanced along the upper margin
of the IIR beneath the peritoneum and fascia transversalis
to come out from the same opening at 9 O’clock where the
short end of the thread was withdrawn out of RN and pulled
outside the abdominal cavity for extracorporeal suture tie.
Before tightening the knot, the scrotum was squeezed and
the intraperitoneal pressure was released to expel the gas in
the hernial sac.

A contralateral internal ring with a patent processus
vaginalis (more than 2 mm) was regarded as a possible cause
of developing clinical hernia and repaired at the same time
[7]. The skin incisions were closed with Steri-strips.

In group B, OH was done through an inguinal skin
cutaneous incision. High ligation of the sac was performed using
4/0, 3/0 absorbable (Monocryl) suture. The distal sac was
slit open to prevent postoperative hydrocele formation. The
wound was closed in layers, using absorbable suture.

All patients were followed up in the out-patient clinic
after 7 days, 2 weeks, 6 months, 1 year, and 2 years. Parents
were advised to contact the department of pediatric surgery,
if there were any concerns in the immediate postoperative
period.

3. Statistical Analysis

The collected data were organized, tabulated, and statistically
analyzed using Statistical Package for Social Science (SPSS)
version 16 (SPSS Inc., USA). Qualitative data, frequency,
and percent distribution were calculated, and Chi square test
was used for comparison between groups. Quantitative data,
mean, standard deviation (SD), and range were calculated,
and for comparison between two groups, the independent
samples (t) test was used. For interpretation of results, P <
0.05 was considered significant.

4. Results

Two hundred and fifty patients with IH were operated upon
by 2 different techniques. Group A (n = 125) was subjected
to laparoscopic assisted inguinal hernia repair by RN. Group
B (n = 125) was subjected to OH. They were 179 males
and 71 females. The youngest was 5 months and the oldest was
96 months, given an overall mean age of 61.56 ± 28.32 months.
All procedures of group A were completed laparoscopically
without any conversion. No intraoperative complications
occurred during this study.

In group A the patients resumed normal activities within
6 hours after surgery, whereas in patients of group B they
resumed normal activities within 10 hours. All patients had
uneventful postoperative recoveries and were discharged on
the same day of admission. The mean hospital stay was
5 ± 3.23 hours with no significant difference between both
groups. There is significant statistical difference between
the studied groups as regards operative time (Table 2). Three
cases developed hydrocele in the early postoperative follow-
up period in group A, while in group B, postoperative
hydrocele was reported in 5 cases. However, all cases
responded well to conservative management within 3 weeks
(Table 3). Over a mean follow-up period of 24 months (range
of 16–30 months), the recurrence rate was 0.8% (one case)
in group A, whereas in group B recurrence rate was 2.4% (3
cases) (Table 3).

In group A, there were no cases of iatrogenic ascent of the
testis, while in group B 4 cases (4.35%) developed iatrogenic
ascent of the testis.

The early cosmetic results for bilateral cases were excel-
ent (Figures 3(a) and 3(b)). At a follow-up examination
more than 6 months later, there were practically no visible
scars in group A, while in group B 5 cases had ugly scars as
Figure 3: (a) Bilateral huge inguinal hernia. (b) Postoperative view.

Table 3: Postoperative complications in the studied groups.

| Groups                  | Group A |          | Group B |          | P value |
|-------------------------|---------|----------|---------|----------|---------|
|                         | Number  | %        | Number  | %        |         |
| Hydrocele               | 3/87    | 2.4%     | 5/92    | 5.4%     | 0.52**  |
| Recurrence              | 1/125   | 0.8%     | 3/125   | 2.4%     | 0.31**  |
| Iatrogenic ascent of    | 0/87    | 0%       | 4/92    | 4.35%    | 0.049*  |
| the testis              |         |          |         |          |         |
| Testicular atrophy      | 0/87    | 0%       | 3/92    | 3.3%     | 0.089** |
| Ugly scar               | 0/125   | 0%       | 5/125   | 4.0%     | 0.024*  |

*Significant, **insignificant.

Figure 4: Right inguinal hernia postoperative view with ugly scar.

reported by parents (Figure 4). The umbilical scars were not visible in all of the patients of group A.

Concerning the outcome of imaging assessment, in group A, there was no significant difference in values of perfusion and size of the testis between preoperative, early postoperative, and late postoperative periods (Figure 5(a)). While in group B; 3 cases (3.3%) had significant diminution of testicular perfusion and size, indicating atrophy (Figure 5(b)).

Duplex scan was performed for all male cases preoperatively and postoperatively for detection of significant changes of testicular blood flow. RI index was calculated, using paired t-test, and P values were obtained in group A.

Table 4 clearly shows that there are significant differences (increase of testicular volume) between preoperative and late postoperative volumes of testis units on the operated side in group A, while in group B it clearly shows that there are significant differences (decrease of testicular volume) between preoperative and late postoperative volumes of testis units on the operated side.

The ratio $v$ was more than 75% in all cases of group A. RI was less than 0.7 in all cases of group A (no atrophy) as shown in Table 5. The ratio $v$ was less than 75% in 3 cases of group B. RI was more than 0.7 in 3 cases of group B (atrophy) as shown in Table 5.

Figure 5: (a) Testicular Doppler U/S showed no signs of ischemia with good blood flow. (b) Testicular Doppler U/S showed poor blood flow.
5. Discussion

In children, the standard surgical treatment of IH is limited to division and ligation of the hernial sac at the IIR without narrowing the ring [5]. The internal ring normally is reached by dissecting the hernial sac from the cord structures. Open herniotomy is an excellent method of repair in the pediatric population. However, it has the potential risk of injury of the spermatic vessels or vas deferens, hematoma formation, wound infection, iatrogenic ascent of the testis, testicular atrophy, and recurrence of hernia. It also carries the potential risk of injury to the vas deferens and testicular vessels, hemato claimed that he is unable to identify any clear benefit of laparoscopic inguinal herniotomy over OH apart from placement of two Z-sutures with good results [17]. Bharathi et al. reported that laparoscopic herniorrhaphy is superior to ovarialis [23]. Lee and Liang performed microlaparoscopic high ligation in 450 patients with good results. They reported no complications of the surgery and a remarkably low recurrence rate (0.88%) [5].

Martel et al. stated that the incision of the peritoneum lateral to the internal inguinal ring and the W-shaped suture, compared to the sole W-shaped suture, is safe and effective in preventing hernia recurrence [24].

Table 4: Evaluation of volume of testis in males of both groups.

| Groups              | Group A (n = 87) | Group B (n = 92) |
|---------------------|-----------------|-----------------|
|                     | Mean volume     | Volume range    | SD    | Mean volume     | Volume range    | SD    |
| Preoperative        | 1.34            | 1.01–1.41       | 0.03*  | 1.35            | 0.89–1.49       | 0.05*  |
| Late postoperative  | 1.36            | 1.21–1.86       | 0.05*  | 1.31            | 0.22–1.56       | 0.12*  |

Statistics
Paired t = 4.73, P value < 0.001*
Paired t = 6.36, P value < 0.001*

Table 5: Duplex evaluation of centripetal artery in males of both groups.

| Groups              | Group A (n = 87) | Group B (n = 92) |
|---------------------|-----------------|-----------------|
|                     | Mean (RI)       | RI range        | SD    | Mean (RI)       | RI range        | SD    |
| Preoperative        | 0.48            | 0.41–0.52       | 0.03*  | 0.48            | 0.41–0.52       | 0.029 |
| Early postoperative | 0.47            | 0.40–0.52       | 0.031* | 0.47            | 0.40–0.52       | 0.031 |
| Late postoperative  | 0.46            | 0.40–0.49       | 0.032* | 0.50            | 0.40–0.78       | 0.037 |

Statistics
Paired t = 75.0, P value < 0.001*
Paired t = 3.02, P value = 0.003*

* Significant.
Open herniotomy in children has been reported to have recurrence rates of 0.8–3.8% [8]. While in laparoscopic hernia repair it is ranged from 0.7% to 4.5%. That is may be due to the presence of skip areas during placement of purse-string sutures as well as the tension resulting from intracorporal knotting particularly in closure of large defects. The critical steps of hernia sac neck transaction at the IIR were not achieved in many laparoscopic procedures unlike during OH. Thus, transient or persistent hydrocele was unavoidable after these laparoscopic techniques. Tsai et al. and others dissected and transected the neck of the sac as unavoidable after these laparoscopic techniques. Tsai et al. and others dissected and transected the neck of the sac at IIR to be followed by a suture closure, with this being a technical modification including injection of saline to lift up the peritoneum, the placement of single suture close by two months of age and 60% by 2 years of age; however, the risk of incarceration is highest during infancy [32]. While in some other series PPVs less than 2 mm were not closed [6]. Our approach has been to ligate all PPVs to avoid the development of metachronous hernia. However, more studies are needed to clarify this point.

For many years, the possible risks of testicular atrophy (0.7–13%), spermatic vessel injury (1.6%), and nerve injury (5–15%) with routine contralateral exploration and repair of PPV in children who have primary unilateral inguinal hernia have been debated [33]. However, in this laparoscopic era, routine exploration and repair of PPV could be a new concept of IH treatment for the following reasons. First, the advantage of laparoscopic hernia repair is the clear and direct view of the vital cord structures that makes dissection of these structures safe and easy. In addition, the incidence of testicular atrophy is so rare in laparoscopic hernia repair because of the multiple collateral circulations of the testis, which makes dissection at IIR level extremely safe even in patients with previous inguinal surgery [34, 35]. Second, the well-known complications with open repair such as iatrogenic cryptorchidism, tethering of the testis and wound infection are almost not seen with laparoscopic repair. Surana and Puri stated that the incidence of iatrogenic asent of the testis after groin exploration for inguinal herniotomy is 1.2% [36]. A total of 173 boys with previous unilateral inguinal herniotomy were subjected to clinical and U/S examination after a mean postoperative period of 31.68 months. One boy (0.58%) had a more than 50% and 10 boys (5.8%) had a more than 25% decrease in testicular volume on the operated side when compared with the nonoperated side [37].

In our study, no single case of testicular atrophy or iatrogenic asent of the testis was reported in group A, while in group B 3 cases of testicular atrophy were reported (Figures 5 and 6). Regarding iatrogenic asent of the testis, no single case was reported in group A, while in group B, 4 cases developed iatrogenic asent of the testis and the difference is statistically significant. Nagraj et al. reported six cases (2.7%) of testicular atrophy after OH (four of the six patients presented with an incarcerated hernia). There were six cases of iatrogenic asent of the testis requiring subsequent orchidopexy (2.7%) [38]. Barqawi et al. reported testicular atrophy in 2 cases (1%) after open surgery [34].

Cosmoses, five-millimeter and 3 mm incisions in group A were, indeed, cosmetically more appealing compared with 2 cm incisions in OH group B (Figures 3 and 4). All parents were satisfied with the cosmetic results of group A.

6. Conclusion

Our series supports the finding of other series that laparoscopic assisted inguinal hernia repair by RN is feasible safe and rapid technique. It resulted in marked reduction of operative time, low rate of recurrence, no testicular atrophy, no
iatrogenic ascent of the testis, and excellent cosmetic results. Complications are minimal though long-term followup will be needed to determine the validity of these results.

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