





Laparoscopic versus open inguinal hernia repair in infants: an initial experience

Samantha Leng ^{*}, Tracy Jackson,[†] Adelene Houlton ^{*}, Elisabeth Dumitriu,^{*} Maurizio Pacilli ^{*‡} and Ramesh Nataraja ^{*‡}

^{*}Department of Paediatric Surgery & Surgical Simulation, Monash Children's Hospital, Melbourne, Victoria, Australia

[†]Department of Anaesthesia and Perioperative Medicine, Monash Children's Hospital, Melbourne, Victoria, Australia and

[‡]Departments of Paediatrics and Surgery, School of Clinical Sciences, Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, Victoria, Australia

Key words

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Correspondence

A/Prof Ramesh Nataraja, Department of Paediatric Surgery & Surgical Simulation, Monash Children's Hospital & Monash University, 246 Clayton Road, Clayton, Melbourne, VIC 3168, Australia.

Email: ram.nataraja@monashhealth.org

S. Leng BMedSc/MD, BMedSc(Hons);

T. Jackson MBChB, FCA, FANZCA;

A. Houlton BAppSc(Hons), MBBS;

E. Dumitriu BMedSc, MD; **M. Pacilli** MBBS (Hons), MD(Research), FRCS(Paed Surg);

R. Nataraja MBBS BSc(Hons) GCCS(Hons) MSurgicalEd FRCSEd (Paed.Surg) FFSFEd SFHEA FRACS (Paeds).

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Abstract

Background: Inguinal hernia repair is a common operation performed in children. In Australia, open repair (OR) continues to be the preferred method of treatment in infants, despite laparoscopic repair (LR) gaining popularity amongst some international centres. Our aim was to analyse initial outcomes with LR at our paediatric centre.

Methods: We conducted a retrospective review of all patients <1 year of age who received LR or OR between January 2017 and July 2021 at our institution. Data were retrieved from both electronic and scanned medical records. Data were analysed using an unpaired *t*-test, Mann–Whitney test, Fisher's exact test or simple linear regression. A *P*-value <0.05 was considered significant.

Results: A total of 376 patients were identified: LR was performed in 73 patients, and OR in 303 patients. Bilateral repair was more common amongst patients receiving LR: 56.2% versus 21.5%, *P* = 0.0001, treating either a symptomatic hernia or an intra-operative contralateral inguinal defect (70%). All LR patients received general anaesthetic, compared to 82.8% of patients in the OR group, *P* = 0.0001. There were no recurrences following LR and 3 with OR (*P* = 1.0). The metachronous contralateral inguinal hernia rate following OR was 10% (21/206). There was no significant difference in other complications, including wound infection, haematoma, testicular atrophy, and hydrocele formation.

Conclusion: In our population OR was performed more often than LR. Operative complication rates were equivalent between OR and LR groups. However, infants that underwent OR were significantly more likely to develop a MCIH.

Introduction

Inguinal hernia repair is a common operation performed in children.^{1,2} Between 0.8% and 5% of infants born at term, and up to 30% of preterm infants are diagnosed with inguinal hernias annually.^{1,2} In infants, operative treatment of an inguinal hernia is typically performed as soon as possible after diagnosis to decrease the risk of incarceration of bowel, testis, or ovary and related morbidity. Risk of incarceration is highest in the <1 year age group and has been reported in 3%–16% of cases.^{2,3}

In Australia, open repair (OR) continues to be the preferred method of treatment for infants <1 year of age despite laparoscopic repair (LR) gaining popularity amongst some international centres. Between the years 2000–2015, the rate of LR in Australian infants <1 year of age only increased by 0.01 per 100 000.⁴ By comparison, in the United States the rate of LR performed in children and infants has increased steadily from 2.7% to 15% since 2009.⁵ Further, in Korean children, a population-based analysis demonstrated an increase from 0.07% to 28.6% of hernias being repaired laparoscopically by 2015.⁶

Known complications of hernia repairs include recurrence of the hernia, testicular atrophy, ascending testis, hydrocele formation and wound infection.⁷ Furthermore, the development of a metachronous contralateral inguinal hernia (MCIH) remains a concern following OR, especially in premature babies. The traditional OR technique is performed in infants with high success and low postoperative complication rates.⁷ Further, the ability to conduct the operation under regional spinal anaesthetic is often cited as a benefit of OR.⁸ Alternatively, proponents of LR, describe merits such as reduced tissue trauma to the inguinal canal structures, and assessment of the contralateral internal inguinal ring.⁷ The International Paediatric Endoscopic Group (IPEG) guidelines found that the LR was faster for bilateral hernia repairs.⁷ Postoperative complication rates (where complications included hydrocele, scrotal oedema, erythema, testicular atrophy and iatrogenic ascending testis) were also found to be lower in LR than OR, and recurrence rates were similar between the two techniques.⁷

With the recent introduction of LR at our tertiary paediatric surgical centre, we aimed to investigate our clinical outcomes from this operation and compare them to a parallel group who underwent OR. We hypothesised that the outcomes would be equivalent between the LR and OR groups.

Methods

Study design

We conducted a retrospective review of all patients <1 year of age who underwent a surgical repair of an inguinal hernia, by either LR or OR technique, between January 2017 and July 2021 at our institution. This study period was selected as LR was first performed in January of 2017, and data collection was conducted in July 2021.

Eligible infants were determined with the use of Medicare Benefits Schedule (MBS) codes (30 612, 60 609, 44 108 and 44 111), including both emergency and elective procedures.

Pre-determined clinical outcome measures were identified and extracted from the institution's scanned and electronic medical

records databases. These data were retrieved from the patients' operation reports, anaesthetic chart, inpatient progress notes, or documented outpatient encounters. For most infants, data were collected from the inpatient admission, during which they had their operation, and from their scheduled outpatient clinic encounter 4–6 weeks following the operation. If infants presented to hospital again following their initial outpatient encounter with any complications relating to their hernia repair, these data were also collected.

Outcome measures

Patient demographics including age, sex, gestation and weight were collected. Our two primary outcomes of interest were MCIH and the rate of hernia recurrence in the OR and LR groups. In infants who received LR, the number of contralateral open internal inguinal rings (COIR) which were repaired on the clinically asymptomatic side were documented. We considered the internal inguinal ring to be open if the distal end of 3 mm Kelly forceps could be introduced at least once centimetre into the defect.⁹ Other known complications of inguinal hernia repairs were evaluated in our study, including wound infection requiring treatment with antibiotics, hydrocele, and testicular atrophy.

Further parameters such as history of hernia incarceration, operative time and method of anaesthesia were also collected.

Surgical technique

The same surgical technique for LR was used by both surgeons performing LR at our institution (MP and RN). An open technique for the insertion of an infra-umbilical 5 mm Hassan port was utilized for the insertion of a Storz 5 mm 30° laparoscope. Lateral abdominal stab incisions of <3 mm were used for the insertion of the laparoscopic 3 mm needle holder and Maryland forceps. A 4/0 Prolene (PROLENE® Polypropylene Suture, Ethicon Inc., Somerville, NJ, USA) suture was used as a purse string to completely close the inguinal canal with intrabdominal knotting. Closure was tested by the non-passage of pneumo-scrotal gas back into the peritoneum. The vas and vessels were preserved under direct visualization.

The standard open inguinal herniotomy technique was performed via an inguinal groin crease incision in the OR group. The external oblique aponeurosis was opened to allow high transfixion of the hernia sac with Vicryl™.

Anaesthetic technique

Patients undergoing LR all received general anaesthesia with an endotracheal tube and controlled ventilation. Analgesia was provided by a combination of infiltration of local anaesthetic to port sites, and systemic opioids.

Most patients undergoing OR received general anaesthesia with either an endotracheal tube or laryngeal mask. Analgesia was provided using a regional technique (caudal block) or local anaesthetic infiltration during surgery. A smaller proportion of patients undergoing OR received awake spinal anaesthesia.

Table 1 Summary of patient demographics in the laparoscopic repair and open repair groups

	Laparoscopic (<i>n</i> = 73)	Open (<i>n</i> = 303)	<i>P</i> -value
Age at operation (months)	2.5 ± 1.6	2.5 ± 2.1	0.9
Gestation (weeks)	34.7 ± 3.9	34.4 ± 3.9	0.6
Male: female	4.2:1	4.5:1	0.9
Birth weight (g)	2182 ± 871	2531 ± 1158	0.5
Weight at operation (g)	4500 (2500–5200)	4400 (1050– 11 200)	0.6
History of previous surgery (<i>n</i> %)	1.4%	7.6%	0.06

Note: Data presented as *n*(%), median(range), or mean ± standard deviation. *P*-values <0.05 are considered statistically significant and bolded.

Statistical analysis

Statistical analysis was performed with the software Prism 9 (GraphPad Prism version 9.0, GraphPad Software, La Jolla, CA, USA). Data are presented as percentage of cases or mean (SD). Categorical data were analysed using Fisher's exact test and continuous data were analysed using an unpaired *t*-test, or Mann–Whitney test for non-parametric data. Simple linear regression was used to determine correlation between date of operation and operating time in the laparoscopic group. A *P*-value <0.05 was considered significant.

Human research ethics committee

This study was approved by the institutional Human Research Ethics Committee (REF: QA/67741/MonH-2020-233 871) prior to commencement.

Results

Patient demographics

A total of 376 infants underwent either LR or OR during the study period (Table 1). There were 73 infants in the LR group and 303 in the OR group. The two groups were comparable for age at the time of operation (*P* = 0.9), the mean age being 2.6 months in the LR group and 2.5 months in the open group. In both groups, 75% of infants who required hernia repairs were born pre-term. The mean birth weight was 2182 g in the LR group and 2531 g in the OR group (*P* = 0.5). The median weight of infants in the LR group at the time of operation was 4500 g as compared to 4400 g in the OR group (*P* = 0.6).

The patients were followed up for a median of 39.2 months (range: 0.25–54 months). A total of 58 infants in the LR group and 226 infants in the OR group presented for their outpatient follow up or re-presented to hospital after their operation. Complications detected within this cohort are summarized in Table 2. No infants in the LR group developed a MCIH, compared to 10% in the OR group (*P* = 0.01). Similarly, no infants in the LR group developed a recurrent hernia, compared to 1.3% of children in the OR group, *P* = 1.0. Significantly more children in the LR group had an

asymptomatic COIR repaired intraoperatively, than children in the OR group that developed a MCIH over the study period; 39.7 versus 10%, (*P* = 0.0001).

When comparing rates of wound infection, haematoma, testicular atrophy, and hydrocele, there were no statistically significant differences between the LR and OR groups. However, a larger proportion of infants in the LR group developed a wound infection compared to the OR group; 5.2% (LR) versus 0.9% (OR), (*P* = 0.06).

Operative technique

More infants in the LR group presented with an incarcerated hernia than in the OR group (Table 3); 5.5% (LR) versus 3.0% OR (*P* = 0.3). Overall, 78.5% of infants in the OR group received a unilateral hernia repair and 21.5% received a bilateral repair. This was significantly different to the LR group, where 43.8% of repairs were unilateral, 16.4% were symptomatic bilateral hernias and 39.7% were incidental COIR repaired intraoperatively.

All infants in the LR group required general anaesthetic for their procedure, compared to 82.8% in the OR group (*P* = 0.0001). The remaining 17.2% of OR infants received only spinal anaesthetic. Infants that required general anaesthetic weighed more than infants that underwent spinal anaesthetic; 4530 g (range: 1050–5200 g) in the general anaesthetic group versus 3568 g (range 1985–6040 g) in the spinal anaesthetic group, *P* < 0.0001. OR was performed by supervised registrars in 65.7% of cases, compared to only 8.2% in the LR group (*P* = 0.0001).

The mean operating time was shorter in the OR group; 37.8 versus 48.0 min for unilateral (*P* = 0.02) and 36.5 min versus 49.3 min for bilateral (*P* = 0.003) repairs. To compare operative time, both symptomatic bilateral hernias and COIR that were found incidentally were analysed together as bilateral hernia repairs. Simple linear regression analysis showed a significant overall decrease in operating times in the LR group for unilateral hernia repairs over the study period, Figure 1. However, there was no significant decrease in operating times for bilateral hernia repairs (*P* = 0.7), Figure 1.

Discussion

This retrospective study has demonstrated that both LR and OR are performed with low complication rates at our institution. Our primary outcomes measures were the rates of MCIH and recurrence of a previously repaired hernia in both LR and OR groups. We found that 10% of infants in our OR group developed an MCIH, marginally higher than the pooled incidence of 7.3% found by Kokorowski *et al.* in a meta-analysis of 129 studies.^{10,11} From our LR cohort of patients, 70% of infants had a COIR that was visualized and diagnosed intraoperatively, with subsequent repair. Although none of these infants had complications from the contralateral hernia repair, these repairs required additional resources, a longer operating duration, and hence extended time under general anaesthesia. Overall, 39.7% of the infants that underwent LR had a COIR. This is consistent with data from published randomized

Table 2 Operative outcomes and complications in the laparoscopic repair and open repair groups

	Laparoscopic (n = 58)	Open (n = 226)	P-value
MCIH (n%)	0	10%	0.01
Recurrence (n%)	0	1.3%	1.0
Wound infection (n%)	5.2%	0.9%	0.06
Haematoma (n%)	0	0.9%	1.0
Atrophy (n%)	0	0	1.0
Hydrocele (n%)	5.2%	4.9%	1.0

Note: Data presented as n(%). P-values <0.05 are considered statistically significant and bolded.

Abbreviation: MCIH, metachronous contralateral inguinal hernia.

Table 3 Operative characteristics in the laparoscopic repair and open repair groups

	Laparoscopic (n = 73)	Open (n = 303)	P-value
Incarcerated hernia (n%)	5.5%	3.0%	0.3
Type of hernia (n%)			
Left	17.8%	33.0%	
Right	26.0%	45.5%	
Bilateral			
Symptomatic	16.4%	21.5%	
Incidental COIR	39.7%	0	
Anaesthetic (n%)			
General	100%	82.8%	
Spinal	0	17.2%	0.0001
Operating time (min)			
Overall	48.6 ± 14.39	37.5 ± 23.34	0.0001
Time unilateral	48.0 ± 10.7	37.8 ± 24.98	0.02
Time bilateral	49.3 ± 16.9	36.5 ± 16.1	0.0003
Surgeon (n%)			
Registrar	8.2%	65.7%	
Consultant	91.8%	34.3%	0.0001

Note: Data presented as n(%) or mean ± standard deviation. P-values <0.05 are considered statistically significant and bolded.

controlled trials, in which the incidence of infantile COIR is estimated at 40%.^{10,12,13}

Notably, our study is limited by the duration of follow up. The natural history of an infantile COIR is not fully understood. There were no MCIHs in our LR group compared to 10% in our OR group ($P = 0.01$) within our study period. This significant reduction MCIHs amongst children receiving LR varies from results of previous randomized controlled trials, that find no difference between MCIH rates with LR and OR techniques.^{14–16} Previous meta-analyses have demonstrated that the number needed to treat (NNT) is 18, such that 18 COIRs need to be closed to prevent one MCIH.^{8,11,17} These studies followed children up to 21 years of age and were likely able to capture the vast majority of MCIH in the analysed populations.^{8,11,17} Amongst 31 100 patients that underwent a unilateral inguinal hernia repair, Lee *et al.* found 63.6% of MCIH presented within 2 years and 91.5% within 5 years.¹⁸ As the follow-up period for our patient cohort is only a median of 39.2 months, it is possible that other infants will develop a MCIH later in childhood or adulthood.

Previous studies have reported a higher recurrence rate with the use of LR.^{15,19,20} A recent meta-analysis by Olesen *et al.* demonstrated that the incidence of recurrence is low (0.3% in LR and 1.1% in OR) and is not significantly different between LR and OR cohorts ($P = 0.34$).²¹ Reflecting the results of these meta-analyses, we found no significant difference in recurrence rates between our LR and OR cohorts.

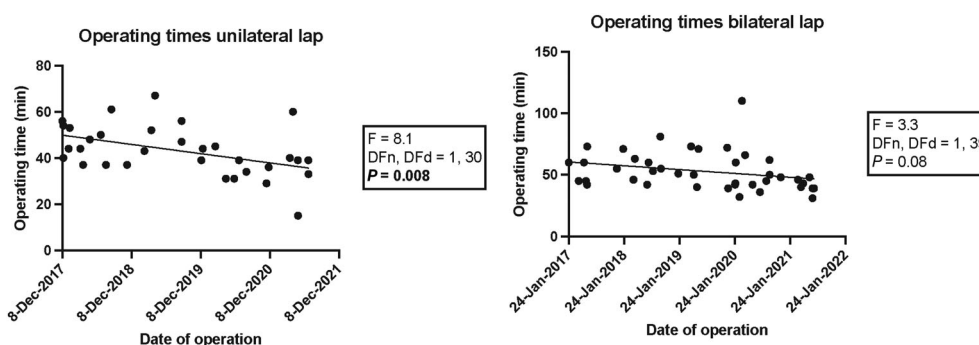
Wound infection, haematoma, testicular atrophy and hydrocele were uncommon in our patient cohort. There were no significant differences between the incidence of these complications in the LR and OR group. However, our ability to detect these complications was limited by the retrospective model of data collection. Not every infant in our study presented for their routine follow up appointment, and it is possible that some infants may have attended other hospitals or healthcare networks. Conversely, the International Paediatric Endosurgery Group (IPEG) Evidence-Based Guideline on Minimal Access Approaches to the Operative Management of Inguinal Hernia in Children found postoperative complication rates to be lower with LR than OR, although the differences were small.⁷

In its introductory phase at our centre, LR is performed by only two of eight consultant paediatric surgeons. This is reflected in the unequal group sizes in our study and is a limitation of our retrospective study design. In all other aspects, the LR and OR groups demonstrated similar baseline characteristics.

Operating time was longer overall in the LR group. This was true for both unilateral and bilateral hernia repairs when compared to the OR group. In previous meta-analyses LR has been associated with longer operating time than OR for unilateral repairs, however, was significantly faster for bilateral repairs.^{7,8,21} Simple linear regression analysis demonstrated a negative trend between time taken to perform LR and the date on which the operations were performed. This suggests that the surgeons performing the operation experienced a learning curve and is in keeping with the experience of the two surgeons who were proficient in the LR technique, having previously performed several hundred, but had not utilized it recently in the years preceding 2017. Previous literature describes a wide range between the number of procedures surgeons need to perform to become proficient at LR.^{22,23} Shibuya *et al.* assessed trainees who performed an average of more than 200 procedures over 13 months, finding an average of 125 procedures were required for surgeons to perform LR in under 20 min.²² Conversely, our relatively small number of cases, 41 bilateral and 32 unilateral repairs, were performed over a 4.5-year period and the two surgeons who performed LR also routinely performed OR. This suggests that longer average operating times in our study may be a result of fewer operations performed overall, or operations not performed in a consecutive fashion and over a longer period. As our study reflects only the initial clinical outcomes of LR at our centre, the longer operating time in our study should be monitored prospectively.

The ability to use awake regional anaesthesia, such as spinal anaesthesia, in OR remains a potential benefit. Infants, particularly with previous neonatal conditions or chromosomal anomalies, are thought to be at higher risk of postoperative apnoea or bradycardia with use of general anaesthetic.^{24–26} Although a recent large observational study demonstrated that type of anaesthetic (general

Fig. 1. Graphical representation of the change in average operating time (minutes) from the beginning of the data collection period to the end of the data collection period for unilateral and bilateral inguinal hernia repairs. Each point on the graph represents an individual operation. A P -value <0.05 was considered statistically significant.



compared to regional) did not influence the risk of a critical event occurring.²⁷ In our study, 81.3% of OR patients still received general anaesthetic. The choice of anaesthetic technique was based on weight, expected surgical length of time, comorbidities, and anaesthetist and surgeon preference.

Conclusion

At our institution, LR is performed in infants less than 1 year of age with minimal complications and are comparable to OR. Our complication rates are in keeping with accepted international standards amongst both LR and OR groups overall. MCIH occur more frequently amongst infants receiving OR and the benefit of closing COIR during LR is still unclear. Operating time with LR at our centre requires further prospective evaluation.

Author contributions

Samantha Leng: Data curation; formal analysis; writing – original draft; writing – review and editing. **Tracy Jackson:** Data curation; formal analysis; writing – review and editing. **Adelene Houlton:** Data curation; project administration. **Elisabeth Dumitriu:** Data curation; project administration. **Maurizio Pacilli:** Conceptualization; methodology; project administration; supervision; writing – review and editing. **Ramesh Nataraja:** Conceptualization; methodology; project administration; supervision; writing – review and editing.

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Conflict of interest

None declared.

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