Original Article

Journey of a Beginner in Minimal Access Surgical Procedures in Pediatric Surgery during initial period of Learning Curve

Surishta K Rana[1], Chandan Gumra[2], Sandeep Singh Randhawa[2], Ulaspreet Singh Bhangu[2]

[1]Assistant Professor (Pediatric Surgery), Department of Surgery, Sri Guru Ram Das Institute of Medical Sciences & Research, Vallah, Amritsar, Punjab, India. [2]Postgraduate Resident Surgery, Department of Surgery, Sri Guru Ram Das Institute of Medical Sciences & Research, Vallah, Amritsar, Punjab, India

Abstract

Background: The aim is to address our experience of Minimal Access Procedures (MAS) in children during the learning curve. **Material and Methods:** This was a retrospective analysis of patients who underwent various types of minimal invasive procedures over last 2 years from August 2023 to August 2025 by new paediatric surgeon just after completion of the training course. The different types of procedures, operative time, conversion rate, complications, Pediatric surgeon's post MCh. duration for individual procedure and serial number of cases was analysed during this learning period. **Results:** A total of 25 patients were present, with age varying from 2Months to 16years of both genders, who had undergone laparoscopic, thoracoscopic and cystoscopic procedures, both basic and advanced type. Simple procedures included laparoscopic cholecystectomies, appendectomies, herniotomies, diagnostic laparoscopy and cystoscopies. Advanced procedures like laparoscopic primary Duhamel pull through, anorectoplasty, ovarian cystectomy, nephrectomy, pyeloplasty and video assisted thoracoscopic surgery were all completed as MAS with no conversion to open. **Conclusion:** Minimal invasive procedure in children is very promising with lot of advantages but are technically demanding requiring lot of patience and precision. Complications occurring during the learning curve cannot be completely nullified but majority of these are surgeon dependent and thus avoidable. The more operative time during the learning curve should not be regarded as a complication or a measure for not proceeding with minimal access.

Keywords: Minimal Access Surgery, Pediatric Laparoscopy, Learning curve, Minimal Invasive.

Received: 25 September 2025 **Revised: 03 October 2025** **Accepted: 27 October 2025** **Published: 14 November 2025**

Introduction

Minimal access has completed two to three decades since its inception. Now almost all the surgical procedures are being done by laparoscopy. Primary goal of a laparoscopic procedure is to achieve good cosmetic outcome, reduced post-operative pain, early recovery and reduced hospital admission. Minimal access surgery (MAS) is being utilised in children to benefit them form long. Although, the interest of performing the MAS in children remained confined to a few enthusiasts initially as most of the pediatric surgeons adopted a wait and see attitude for including MAS in their routine practice.[1-3] However with increasing experience in pediatric laparoscopic procedures and advances in instrumentation, minimal access has become accepted in the modern pediatric surgical armamentarium.[4-6]

The laparoscopic surgery in children is increasing worldwide and the need for laparoscopic training has become essential in every teaching hospital. In this modern times it is very essential that every pediatric surgeon must have adequate training in laparoscopy. However, the learning curve in pediatric laparoscopy is long due to less working space, more complications and thus high conversion rate during the learning curve. With the improvement in skill, the conversion rate and complications decrease with time during the learning curve.

This article presents a young pediatric surgeon's experience of minimal access procedures over 2years of the beginning of practice after completion of training and also included the timeline in months for each procedure from the post training period. The author, thus aims to share self-experience of the initial MAS journey, for motivating the beginners to start the utilization of the minimal access from the start of their practice while ensuring the child safety by avoiding all the complications and be prepared for handling complications that might happen during such procedures. A thorough knowledge of the surgical procedure, anatomical planes for dissection in particular type of surgery and anatomical variations that can be encountered, all of these tend to be the main prerequisites and can never be substituted in any case.

Aim & Objective: The main objective of this study is to see the safety and feasibility of performing all minimal access surgical (MAS) procedures especially the advanced laparoscopic or

Address for correspondence: Dr. Surishta K Rana, Assistant Professor (Pediatric Surgery), Department of Surgery, Sri Guru Ram Das Institute of Medical Sciences & Research (SGRDIMSR), Vallah, Amritsar, Punjab, India
E-mail: drsrishtyrana66@gmail.com

DOI:
10.21276/amit.2025.v12.i3.100

How to cite this article: Rana SK, Gumra C, Randhawa SS, Bhangu UPS. Journey of a Beginner in Minimal Access Surgical Procedures in Pediatric Surgery during initial period of Learning Curve. Acta Med Int. 2025;12(3):381-386.

thoracoscopic ones in beginning of the learning curve of a pediatric surgeon in relatively newer institute settings for such procedures.

Materials and Methods

Patients ranging from 2Month age up to 16years were managed with minimal access procedures by a single pediatric surgeon having adequate exposure for all type of MAS procedures as an assistant during pediatric surgery training period but minimal prior hands-on practice for the same during training period. After completion of the pediatric surgery training in June 2023, author made minimal access procedures as the part of clinical practice from the very start of clinical journey at Department of Surgery, SGRDIMSR, Amritsar, Punjab. Due to low volume centre especially for pediatric surgery referrals, surgeon could perform a total of 204 surgeries over two years, from August 2023 to August 2025, out of which 25 patients underwent minimal access surgical procedures. MAS procedures performed included Laparoscopic surgeries, Thoracoscopic surgery and Cystoscopic procedures. All the procedures were performed by single pediatric surgeon with a junior resident as the assistant surgeon. Post operatively patients were managed in pediatric general ward or pediatric intensive care unit if less than 2year age or in cases of patients having an emergency admission and all the case of more than 2year age having routine elective admission were managed in general surgery ward as per institutional protocol. In laparoscopic procedures, pneumoperitoneum was created by open method in all patients using carbon dioxide. The intra-abdominal pressure was maintained at 6-8 millimetre of mercury (mmHg) in infants with flow rate 1 litre/minute (L/min) and 10-12 mmHg with flow rate 2-3 (L/min) in older children. Ventilation parameters like respiratory rate and tidal volume were adjusted by the anaesthetist to maintain the end tidal carbon dioxide partial pressure (PetCO2) levels in normal range (35-45mmHg). Invasive monitoring for blood gas partial pressures was done in two surgeries of larger duration. Video assisted thoracoscopic surgery (VATS) procedure was performed by creating pneumothorax using CO2 pressure of 4-5 mmHg and flow rate at 1 L/min. All procedures were done using basic laparoscopic instruments with monopolar and bipolar electrocautery as the energy devices in nearly all cases except the use of harmonic device in only one case. All cystoscopic procedures were performed using 6F pediatric cystoscope except one bigger patient requiring 16F cystoscope. Saline was used for irrigation for short procedures less than 15minute and glycine irrigation used for cystoscopic procedures of duration more than 15minutes especially for those requiring the use of electrocautery. Cystoscopic procedures for diagnostic purpose or stent removal were performed as day care procedures while other cystoscopic procedures like valve fulgurations required admission for 1-2 postoperative days. All types of MAS procedures, operative duration, complexity of procedure, intraoperative complications, conversions to open and postoperative complications during initial 2year of learning curve were analysed.

Results

Our study group consisted of patients of age group ranging from 2 months to 16 years with median age 8 years. Of total 25 patients, 18 (72%) were males and 7 (28%) females. Of all MAS procedures, laparoscopic surgery was the most common performed in 16 (64%) patients, followed by cystoscopic procedures in 8 (32%) and thoracoscopic procedure in 1 (4%) patient. Out of 16 laparoscopic surgeries 14 patient underwent simple and advanced gastrointestinal GIT) procedures, while 2 patients underwent advanced urogenital surgery procedures. Of all the MAS procedures, 17 (68%) patients underwent simple procedures while 8(32%) were advanced procedures. Laparoscopic (GIT) surgeries in our patients included simple procedures like laparoscopic appendectomy, cholecystectomy and diagnostic laparoscopy, while advanced procedures as primary Duhamel pull through for Hirschsprung's disease and laparoscopic anorectoplasty for one male and one female anorectal malformation. Laparoscopic urogenital surgeries included two simple MAS procedures of laparoscopic herniotomy for inguinoscrotal swellings and rest were advanced procedures as one laparoscopic ovarian derotation with cystectomy procedure for large ovarian chocolate cyst with torsion, one laparoscopic Nephroureterectomy for hydroureteronephrosis with Pyonephrosis and one laparoscopic pyeloplasty for Pyeloureteric junction obstruction (PUJO). Thoracoscopic surgery was one advanced procedure (VATS) for Complex empyema in case of penetrating trauma with diaphragmatic and gastric fundus injury who had undergone previous emergency laparotomy for injury repair along with chest tube insertion

Advanced Minimal access surgery (MAS) was utilised for all mentioned organ systems (GIT, urogenital & thoracic) for both simple as well as advanced procedures. No intraoperative complications like bleeding, iatrogenic injury to bowel, bile duct, lung, pericardium or any neurovascular structures, were encountered during these MAS procedures in any of the patients. None of our laparoscopic or thoracoscopic procedure needed intraoperative conversion to open. Conversion was not applicable for cystoscopic procedures, although all of them too were uneventful. Cystoscopic procedures included cystoscopy in two patients for posterior ureteral valve fulgurations, urethral stricture management, cystoscopic stent removal and diagnostic cystoscopy genitoscopy or fistuloscopy. Mean operative duration was 123 minutes, ranging between 5 to 450 minutes. Longest duration of procedure was observed for laparoscopic Duhamel Pull-through (450 minutes) and shortest for cystoscopic stent removals (5–10 min). Blood loss during all surgeries was minimal and intraoperative blood transfusion was needed even in any of the advanced MAS procedures. One patient that was of longest duration was kept electively intubated on the day of surgery in view of prolonged anaesthesia and extubated on 1st postoperative day (POD), although there were no blood gas changes or any physiological issue in the patient. Rest of all our cases were extubated on table and managed in routine postoperative ward. Of all patients, postoperative complication was observed in 5 patients. All these were advanced MAS procedure case, out of which 4 cases had minor issues (one each of wound infection, fever, ileus, minor urinary leak) which were

managed conservatively. One advanced MAS case developed leak for which revision surgery was done, which subsequently recovered well and discharged uneventfully. Mean postoperative discharge for our MAS procedures was 2.4 days. All patients were regularly followed in postoperative period and all of them are doing well. Minimal follow up period in our cases is 1month and that is the last operated case of laparoscopic hernia repair and is completely doing well. All our observations are shown in [Table 1] below in detail.

Table 1: Table showing the observations of our study based on Minimal Access Surgery Procedures

Various MAS Types (n=25)	MAS Complexity (n=25)	Duration Range (in minutes)	Drain Insertion (n=5)	Total Complications Observed (n=5)		Conversion to Open (n=0)	Discharge Postoperative Day
				Intraoperative	Postoperative		
Laparoscopic n=16 (64%)	Simple n=11 (68.8%)	45-120 (mean=82)	n=2 (18.18%)	Nil	Nil	Nil	1-4
	Advanced n=5 (31.2%)	60-450 (mean=138)	n=2 (40%)	Nil	n=5 (4minor/1major)	Nil	2-7
Cystoscopic n=8 (32%)	Simple n=6 (75%)	5-35 (mean=20)	-	Nil	Nil	-	1-2
	Advanced n=2 (25%	40-75 (mean=58)	-	Nil	Nil	-	2-3
Thoracoscopic n=1 (4%)	Simple nil	-	-	Nil	Nil	-	-
	Advanced n=1 (4%)	210	n=1 (100%)	Nil	Nil	Nil	6
Total	Simple n=17 (68%)	5-120 (mean=50)	n=2 (11.76%)	Nil	Nil	Nil	1-4 (mean=2.3)
	Advanced n=8 (32%)	40-450 (mean=140)	n=3 (37.5%)	Nil	n=5 (4minor/1major)	Nil	2-7 (mean=4.1)

Our data was analysed statistically for observing the operative duration correlation with other variables using Pearson Correlation Coefficients. MAS procedure complexity (simple or advanced) was observed as the strongest predictor of the longer operative time as advanced procedures consistently take more time. Postoperative complications and intraoperative drain insertion were observed to increase with duration, suggesting intraoperative complexity. Delayed discharge was more common after longer surgeries, especially advanced laparoscopy and thoracoscopy. Surgeon experience also shows a mild positive correlation, showing that surgeon with gaining experience in each case, tend to handle advanced cases with longer duration, possibly due to gain in experience and confidence. These observations are shown in [Table 2 and Figure 1].

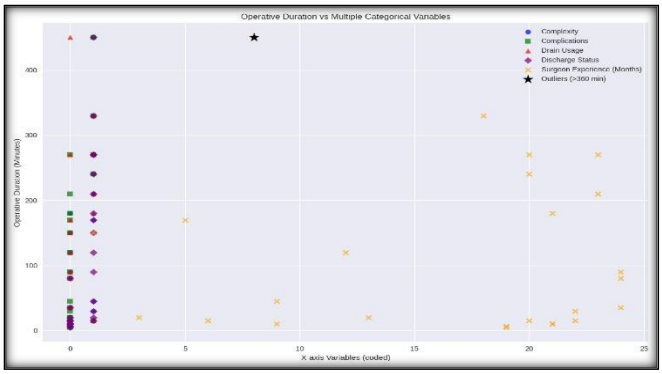

Figure 1: Scatter plot diagram showing correlation of operative duration with procedure complexity, complications, drain usage, hospital stay and surgeon experience.

Table 2: Pearson Correlation Coefficients for operative duration with all the other variables

Variable	Correlation with Operative Duration	Strength	Direction
Procedure Complexity	+0.74	Strong	Positive
Complications	+0.48	Moderate	Positive
Drain Usage	+0.42	Moderate	Positive
Discharge Status	–0.55	Moderate	Negative
Surgeon Post-Training Duration	+0.36	Mild	Positive

The complexity (simple/ advanced) of the procedure, affects the operative duration and postoperative duration of hospital stay in statistically significant manner (p- values <0.05). Although there was no independent effect of complexity or operative duration on the conversion rate in all of our simple and advanced MAS procedures as there was no conversion to open noted in any of our cases. These results are shown in [Table 3].

Table 3: Statistical comparison in between duration and complexity independently and along with complications, discharge and conversions

Comparison	p- value	Significance
Duration vs Complexity	0.001*	Highly Significant
Duration vs Complication	0.014*	Significant
Complexity vs Complications	0.068	Borderline association
Complexity vs Discharge	0.008*	Highly significant
Duration/Complexity vs Conversion	-	No Conversion
*p value <0.05 considered as significant		

Operative pictures related to various advanced MAS procedures performed in our patients are shown in Figure A, B, C, D below:

Figure (A): Port insertion for laparoscopic Anorectoplasty in anorectal malformation. Note the drapes and gauze covering colostomy site secured in place using sterile transparent ioban sheet

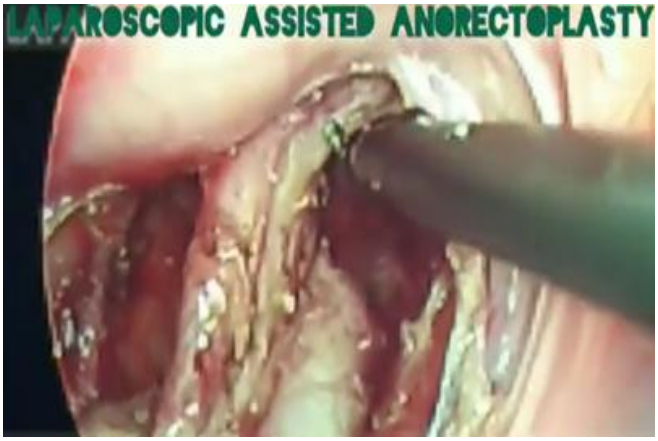

Figure (B): Rectoprostatic fistula dissection in anorectal malformation while fistula dissection in proximity with the urinary bladder.

Figure (C): Laparoscopic primary Duhamel pull through showing dissected sigmoid brought out retrorectally, following which aganglionic segment was resected and anastomosis completed with posterior rectal wall above dentate line

Figure (D): Nephroureterectomy specimen delivered from umbilical port site in laparoscopic procedure for nonfunctioning pyonephrotic kidney and tortuous ureter

Discussion

Pediatric surgery has a wide scope of work, ranging from basic to advanced procedures from both open to minimal access ones. Ethically, all the children should be in the frontline of the beneficiaries for all the simple to advanced Minimal Access Surgical Procedures, beyond all the constrains for availability and accessibility based on any child's location. While the availability and accessibility for such procedures for pediatric patients, is never a problem for a child living in Tier 1 or Tier 2 city but this is extremely different for Tier 3 cities. Adequate training of all pediatric surgeons in MAS procedures during training and utilization of these procedures from the start of their clinical practice can only thus bridge this gap. Operative setups and enhanced postoperative care facilities too are needed for these areas for providing MAS procedures benefits to all the children. The main advantages of laparoscopy surgeries like less pain, better visibility of all structures while surgeries in deep cavities of small children, less scar, shorter hospital stay, early return to normal activities, early return to school, early resumption to work by parents etc should be provided to all the children. More the pediatric surgeons start utilising these MAS procedures in their practice routinely, the more widely will these procedures become available for the children. However, all these MAS procedures are not without complications and also there is a learning curve for acquiring the skillset needed for advanced procedures and need for upgradation of the acquired skill is also constantly required.

In our study, majority of MAS procedures were laparoscopic surgeries (64%) and rest were cystoscopic (32%) and thoracoscopic procedures (4%). Dominance of laparoscopic procedures in MAS procedures is because of universal application in both GIT and urogenital diseases as seen in our patients. Learning curve of laparoscopic, thoracoscopic and cystourethroscopy surgeries all vary in pediatric patients. Different studies provide data on learning curve in pediatric cases for different surgeries like, laparoscopic cholecystectomy learning curve ranging from 10 to 75 procedures, fundoplication learning curve is 25 procedures, splenectomy learning curve is minimum of 20 cases and for pyloromyotomy learning curve is 35 procedures.[7-10] Thoracoscopic surgery like VATS has learning curve of approximately 30 cases in different studies. Cystoscopic procedure for endofulgration also need precise control in handling cystoscope for electrocautery use in pediatric

posterior urethra for fulgurations and other therapeutic MAS procedures. Early period of the learning curve may be very uncomfortable for the surgeon, especially when excellent results are achieved by open surgery for similar condition by same surgeon and this becomes the biggest reason for most of the pediatric surgeons not initiating at all or delaying their minimal access journey and few of those who have started may feel to withdraw after encountering complications, because of the pressure of constantly delivering optimal results. Pediatric surgeons who are in early phase of MAS learning curve, may withdraw at the first place, especially advanced laparoscopic or thoracoscopic ones, due to fear of complications, constrains of small working space that makes the procedure more difficult, more conversion rate and lack of desired results. Pediatric surgeon needs to leave the comfort of free working space available during the open surgery to start minimal access journey and accept the constraints and challenges of minimal access during the learning curve, for the long-term benefit of their patient during their entire practice. Those who accepts the challenges during learning curve and progress in learning can only later become proficient in their minimal access skills. Many pediatric surgeons are in their learning curve as shown in a recent survey.[7]

Of all the complications of minimal access surgery, majority of them are technique related. The dreaded complications are visceral or vessel injury during trocar insertion, diathermy injury to bowel, vessels, bile duct, bladder, ureter and seminal vesicles, posterior urethra, vagina or cervix during deep pelvic dissections. Complication rate of 1-2% has been reported in laparoscopic surgery in children in large centers.[11] No intraoperative complications were observed in our patients. The more operative time should not be considered as complication, especially for advanced procedure, as this is very important and safe for the surgeon to avoid the complications during early learning curve and also helps to gain the confidence while completing the procedure safely. Conversion of a MAS procedure to open should always be opted by the surgeon to prevent the complication in case of difficult dissections or bleeding.

Although, no conversion to open occurred during any of our simple or advanced MAS procedure. Thus, intraoperative complications and conversions can be avoidable also for advanced procedures too, even during the very beginning of the learning curve as observed in our cases. Postoperative minor issues were observed in 4 of our advanced complex procedures all of which were managed conservatively, while one had urinary leak who required revision procedure. In our observation, the intracorporeal suturing was the major technical benchmark especially for the reconstruction procedures, that every laparoscopic surgeon struggles and need to achieve during the learning curve. Although the learning curve for laparoscopic suturing varies in various studies ranging for as many as minimum 20 cases to 37 or more, yet the surgeon's aptitude highly impacts the suturing ability for achieving the proficiency.[12] Operative duration for the advanced procedure too, tends to decrease over time as observed in our study.

Pediatric surgeon's period of starting MAS procedures, after completion of training was 1month and the study analysis was done over the patients operated in initial two years of MAS journey. Our study suggests that, both feasibility and safety of the MAS exist during the early learning curve of a pediatric surgeon post training. Advanced surgical procedures seen conducted in this study within early post training period with laparoscopic management of large ovarian haemorrhagic cyst with torsion in 15year female with operative duration 170minute as just 3rd case in serial order at 5month, followed by laparoscopic primary Duhamel pull through surgery in 8year boy with maximum operative time of 450 minute, who was operated as 5th case in serial order, at 8month post training duration also depicts the safety and feasibility of MAS procedures for advanced surgeries in early learning curve. The bare number of the pediatric cases presenting to the institute was the most limiting factor for the surgeon, yet that factor too could not limit the surgeon from performing minimal access procedures from all simple to complex types, from the very beginning.

Assistant surgeon handling the telescope while a laparoscopic or thoracoscopic surgery also adds to the ease or difficulty based on the prior experience, thus affecting the duration too. Although, all of these procedures were performed with general surgery post graduate residents as assistants for whom handling camera was relatively newer, yet the procedures were conducted safely and effectively in single pediatric surgeon's hands. MAS procedures thus can be performed safely by pediatric surgeon in beginning of the clinical practice post training, provided the surgeon is confident enough to deliver the required accuracy, precession and has immense patience to be persistent in complex dissections to finish off the procedure with minimal or no complications keeping child safety as the highest priority. Also, in cases where inadvertent event happens intraoperatively or postoperatively, that should be efficiently managed well in time.

Conclusion

MAS procedures in the pediatric patients can be performed safely and effectively, even in the resource limited settings by a young beginner pediatric surgeon, provided the centre is well-equipped for handling all such pediatric patients. Thus, the navigation though the learning curve for pediatric surgeon can be independent too, even if the separate functioning pediatric surgery department not there or no other senior pediatric surgeon is there to mentor or standing by. Postdoctoral residents of pediatric surgery should be trained hands-on for minimal access procedures, so that they are confident enough to deliver minimal access procedures at just the start of their own clinical practice with good results and thus making these procedures more widely available for the use of all the children. Both operating time and complication rate tends to fall, down the learning curve as per this study and study shows that conversion rate even at the start of learning curve is completely dependent on the surgeon's precision and patience to carry and complete the procedure.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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