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Experience Of Minimally Invasive Surgery In Neonates With Congenital Malformations

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Abstract

Introduction

Minimally invasive surgery (MIS) has revolutionized the approach to surgical interventions in neonates with congenital malformations, offering distinct advantages over traditional open surgeries. Neonates born with congenital malformations often require surgical interventions early in life to correct or alleviate associated issues. Historically, these surgeries have predominantly been performed through open approaches, which pose significant challenges and risks in the delicate neonatal population. However, with advancements in medical technology and surgical techniques, minimally invasive surgery (MIS) has emerged as a promising alternative.

Material and Methods

A prospective observational study was conducted in a tertiary-care level neonatal intensive care unit (NICU) of the Pediatric Hospital. The following data were recorded: gestational age, birth weight, sex, diagnosis, associated malformations, age and weight at surgery, surgery duration, conversion to open surgery, intraoperative bleeding, intraoperative complications, pre- and post-operative arterial pressure of carbon dioxide ($paCO_2$), postoperative morbidity surgery-related, type and duration of postoperative analgesia, postoperative mechanical ventilation duration, fasting time, postoperative hospitalization, and mortality surgery-related.

Conclusion

MIS represents a paradigm shift in the surgical management of neonates with congenital malformations, offering significant benefits in terms of reduced morbidity, faster recovery, and improved cosmetic outcomes. Continued advancements in technology and surgical techniques are likely to further enhance the applicability and effectiveness of MIS in this vulnerable patient population.

Keywords: Congenital malformations, Invasive surgery, Neonates.

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Introduction

Minimally invasive surgery (MIS) has revolutionized the approach to surgical interventions in neonates with congenital malformations, offering distinct advantages over traditional open surgeries. [1] Neonates born with congenital malformations often require surgical interventions early in life to correct or alleviate associated issues. [2] Historically, these surgeries have predominantly been performed through open approaches, which pose significant challenges and risks in the delicate neonatal population. However, with advancements in medical technology and surgical techniques, minimally invasive surgery (MIS) has emerged as a promising alternative. [3]

MIS techniques involve smaller incisions compared to open surgery, leading to reduced tissue trauma and scarring. This is particularly beneficial in neonates, where minimizing trauma can accelerate recovery and reduce post-operative complications. [4] Smaller incisions in MIS result in reduced exposure of internal organs to the external environment, lowering the risk of infections—a critical consideration in neonatal surgical care. [5]

Neonates undergoing MIS often experience shorter hospital stays and quicker recovery times compared to those undergoing traditional open surgery. This facilitates earlier initiation of feeding and bonding with parents. [6] The cosmetic results of MIS are superior due to smaller incisions, which can be particularly important for neonates requiring multiple surgeries over their lifetime. [7]

Enhanced Visualization and Precision: MIS techniques, such as laparoscopy and thoracoscopy, provide surgeons with magnified views and precise control of surgical instruments, allowing for meticulous handling of delicate neonatal tissues. Congenital Diaphragmatic Hernia MIS has been increasingly used for repair, offering reduced morbidity and faster recovery compared to open surgery. [8]

Thoracoscopic repair of esophageal atresia in neonates has shown promising outcomes in terms of reduced postoperative complications. Gastroschisis and Omphalocele: Closure of abdominal wall defects using MIS techniques has become standard practice in many centers, minimizing complications associated with prolonged exposure and facilitating faster bowel function recovery. [9]

While MIS offers numerous advantages, it also presents challenges in terms of technical expertise, equipment availability, and patient selection criteria. The small size of neonatal anatomy necessitates specialized training and precise instrumentation.

Material and Methods

A prospective observational study was conducted in a tertiary-care level neonatal intensive care unit (NICU) of the Pediatric Hospital.

Inclusion criteria

Patients experiencing hemodynamic and respiratory stability at the time of surgery, regardless of gestational age, weight, or the need for mechanical ventilatory support before undergoing surgery. No patient had high-frequency ventilation at the time of surgery.

All surgeries were performed using basic instruments (Maryland dissector, monopolar energy, atraumatic forceps, and endoscopic scissors). In some cases, an electronic dissection

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device (cordless ultrasonic device) was used. A 5-mm high-definition camera was used at 30° in all procedures.

Laparoscopic surgeries were performed with patients assuming the supine position using two or three 3-mm work ports. The primary port was inserted with an open technique in the left supra-umbilical region, transcutaneous points were used to expose the surgical area, and 5-0 G sutures with a 3/8 needle (11–13 mm) were used. CO_2 insufflation was performed with pressures of 4–6 mmHg and flows of 1–3 L/min.

Thoracoscopic surgeries were performed with patients in the supine lateral position of the affected side at 45°. Two or three 3-mm work ports were used. Pulmonary collapse with CO_2 insufflation was obtained with positive pressures of 4–6 mmHg. In most cases, transcutaneous sutures were used to elevate the adjacent tissues and obtain better visibility. In congenital diaphragmatic hernia (CDH), to prevent organ injury, atraumatic instruments were used gently, and cotton tape pulled by two instruments was used to reduce the spleen back into the abdominal cavity. To perform these procedures, adequate muscle relaxation by the anesthesiologist was necessary. In some patients, a thoracic drainage tube was inserted through the lower port.

In both laparoscopic and thoracoscopic surgeries, the ports were fixed to the skin with transcutaneous sutures to prevent mobilization during the procedure, and the diameter of the insufflation tube was reduced using an extension intravenous tube.
All patients were monitored by electrocardiography, noninvasive blood pressure monitor, pulse oximeter, axillary skin temperature, and end-tidal CO_2 monitor. Blood gases were obtained during the surgical procedure. All procedures were performed by the same surgeon but with different anesthesiologists.

Statistical analyses

Descriptive statistics were used, with the calculation of frequencies and percentages and measurements of central tendency, median, and range. Wilcoxon or Chi-squared tests were used for comparison between groups.

Results

Table 1: Associated Congenital Malformations In The Newborns Based On The Type Of Surgical Procedure

Type of procedure/Type of malformation	
Thoracoscopic surgery	15/23 (65)
EA/TEF repair	8/11 (72)
VACTERL association	5
Ventricular septal defect	2
Down syndrome	1
Craniosynostosis	1
Bronchogenic cyst	1
Multiples anomalies	1
Bochdalek-type CDH repair	5/12 (41.7)
Fryns syndrome	2
Simpson-Golabi-Behmel syndrome	2
Down syndrome	1

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Coarctation of the aorta	1
Suspected Okihiro syndrome	1
Diaphragmatic plication	5/5 (100)
Complex congenital heart disease	4
Cystic adenomatoid malformation	1
Laparoscopic surgery	1)
Fundoplication/gastrostomy	6/12 (50)
Esophageal atresia type 1	6/10 (60)
VACTERL association	2
Neuronal migration disorder and renal anomalies	2
Mesenchymal hamartoma of the chest wall and rib agenesis	1
Hydrocephalus	1
Dilated myocardiopathy	1
Suspected Smith-Lemli-Opitz syndrome	1
Morgagni-type CDH repair	1
Noonan syndrome	1/1 (100) 1/4 (25)
Duodenal atresia repair	1/4 (25)
Intestinal malrotation	1
Pancreatectomy	1/3 (33.3)
Ventricular septal defect	1
Total	22/45 (48.9)

Table 2: Intraoperative Complications And The Reasons For Conversion To Open Surgery

Procedure	Intraoperative complications (%)	Reasons for conversion (%)
Thoracoscopic		
EA/TEF repair	2/11 (18.2)	**1/22 (4.5)**
CDH repair	Decreased O_2 saturation and bradycardia (4) 2/8 (125)	**Poor visibility (1)*** **2/8 (25)**
	Decreased O_2 saturation and bradycardia (2) Gastric and colon perforation (1)	**Technical difficulty (2)**** **Poor visibility (1)**
Diaphragmatic plication	1/5 (20)	**0**
	Pneumothorax (1)	
Laparoscopic		
Fundoplication/gastrostomy	0	**1/10 (10)**
		Poor visibility (1)***
Jejunal atresia repair	1/2 (50)	**0**
	Bradycardia (1)	
Duodenal atresia repair	0	**0**
Pancreatectomy	0	**0**
Morgagni-type CDH repair	0	**0**

Total	**5/45 (11.1)**	**3/45 (6.7)**

Table 3: Postoperative Characteristics In Thoracoscopic And Laparoscopic Surgery

	Thoracoscopic surgery (*n*=46)				**Laparoscopic surgery (*n*=25)**				
	EA/TEF repair	**CDH repair (*n*=8)**	**Plication (*n*=5)**		**Fundoplication/ gastrostomy**	**Duodenal repair**	**Pancreatectomy (*n*=2)**	**Jejunal repair**	**MDH repair**
	(*n*=11)				**(*n*=10)**	**(*n*=2)**		**(*n*=2)**	**(*n*=1)**
Type of analgesic									
Buprenorphine (n)	11	7	4		8	2	2	1	**0**
Fentanyl (n)	2	4	0		0	0	2	1	**0**
Morphine (n)	0	2	0		0	1	0	0	**0**
Ketorolac (n)	8	5	3		7	2	2	1	**1**
Duration of analgesia (days)	2 (3-5)	2 (1-7)	2 (1-4)		2 (2-4)	2 (3-6)	2 (2-3)	2 (3-5)	**2**
MV duration (days)	3 (1-25)	5 (1-14)	2 (1-6)		3 (0-7)	2 (1-3)	1	2 (2-4)	**4**
Preoperative $paCO_2$ (mmHg)	16 (25-64)	18 (21-56)	16 (28-54)		23 (20-77)	17 (14-40)	23 (42-49)	14 (23-35)	**15**
Postoperative $paCO_2$ (mmHg)	19 (17-61)	24 (26-67)	17 (30-62)		17 (23-60)	21 (30-45)	22 (43-47)	15 (26-32)	**13**
Fasting time (days)	4 (3-20)	3 (2-16)	1.5 (1-4)		4 (2-6)	6 (7-17)	3	4	**3**
Hospital stay (days)	**7 (3-123)**	**8 (2-111)**	**4 (2-9)**		**5 (5-21)**	**11 (10-57)**	**3 (3-7)**	**5 (8-13)**	**5**

Table 4: Postoperative Morbidity According To The Surgical Procedure

Thoracoscopic surgery (*n*=46)	**n (%)**	**Laparoscopic surgery (*n*=25)**	**n (%)**
EA/TEF repair	6/12 (50) *	Fundoplication/gastrostomy	**1/10 (10)**
Esophageal stricture	5	Leakage from gastrostomy site	**1**
GERD	3	Jejunal atresia repair	**2/2 (100)**
Anastomotic leak	2	Anastomotic leak	**1**
Sepsis	2	Intestinal obstruction/enterocutaneous fistula	**1**
Pleural effusion	2	Duodenal atresia repair	**2/4 (50)**
CDH repair	7/14 (50) *	Anastomotic leak	**2**
Pleural effusion	2	Morgagni-type CDH repair	**0/1**
Sepsis	2	Pancreatectomy	**0/3**
Pneumothorax	2		
Chylothorax	2		
Pneumonia	2		

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GERD	2		
Intestinal perforation and intra-abdominal abscess	1		
Diaphragmatic plication	1/5 (20)		
Recurrence eventration	1		
Total	**11/22 (50)**		**5/25 (20)**

Discussion

MIS in the neonatal surgery has been safe, effective and provides the same benefits as its open counterparts. [10] But these successes have not been universal and trail leaders like Rothenberg, Holocomb, Georgeson and Lobe have played very substantial role in introduction of MIS in the neonates during last 20 years at most. [11] Adaptation of MIS among these small babies as the surgical default has been slow to develop worldwide, and only after the introduction of 2/3 mm instruments were made available, that too only in advanced centers. [12]

In a series by Iwanka et al. complication rates after pyloromyotomy was as high as 9.7% and a meta-analysis by Hall and colleagues found that overall complications like mucosal perforations and incomplete pyloromyotomy was higher. [13] Whether MIS for congenital duodenal obstruction is superior to open approach still remains controversial evident from a very recent study. High leakage rate, anastomotic stenosis, missed distal duodenal obstruction makes open procedure still the operative procedure of choice. [14] Complex biliary reconstructions are challenging even in the hands of experienced laparoscopic surgeons. Increased recurrence rate is reported in case of laparoscopic inguinal hernia repair. The first multi-center, multi- surgeon review of esophageal atresia and TEF repair has shown results comparable to open thoracotomy, but the procedure itself has a steep learning curve and should be performed only by experienced MIS surgeons. [15]

There has been increasing interest in attempting MIS for repair of congenital diaphragmatic defects in the neonatal period. But selection criteria for thoracoscopic repair are not well developed because of the effects of iatrogenic pneumothorax and its consequences; not all are good candidates for repair thoracoscopically and more studies are required to set up criteria. Furthermore, no consensus exists about which way to approach, thoracic or abdominal. [16] There are suggestions that de- spite the very rapid growth of MIS in the neo- nates, its application should not be considered as a direct alternative of techniques used in older children [17].

A very important issue is the involvement and interests of the manufacturers who produce MIS instruments for surgical use. Various 10mm and 5mm instruments used for adult MIS are the areas of concentration for the manufacturers because of the profits they make with increased volume of their use in adult population. That is the irony of present global open market economy all over the world and the neonatal surgeons are at their pity too. Manufacturers have been slow to produce products especially adapted to small babies. Many needs are still to be made. No 3mm, 20 cm shears, 3mm endoscopic clips are available till date compelling surgeons to use larger in- struments. [18] Rothenberg must be credited for his extraneous efforts to be able to convince the industry, that they needed to produce these tools, and the key was that there was an adequate market so that it made financial sense. [19]

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Advancement of techniques and instrumentations should aid in the development of MIS among the neonates. Newer advances like Robotics in surgery looks promising in curtailing technical difficulties faced during traditional MIS. NOTES (Natural Orifices Endoluminal Surgery), and SILS (Single Incision Laparoscopic Surgery), mini-laparoscopy are now possible in the pediatric age and may prove successful in neonates as well. Newer, more sophisticated endosuturing devices, safer energy devices, slow-flow insufflators are all to provide safer MIS among neonates. Two mm instruments are now available in advances centers obviating the need for trocar insertion. [20]

Conclusion

MIS represents a paradigm shift in the surgical management of neonates with congenital malformations, offering significant benefits in terms of reduced morbidity, faster recovery, and improved cosmetic outcomes. Continued advancements in technology and surgical techniques are likely to further enhance the applicability and effectiveness of MIS in this vulnerable patient population.

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