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Open vs Thoracoscopic Repair in Congenital Diaphragmatic Hernia: A Comparative Study

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Abstract: Background: Congenital diaphragmatic hernia (CDH) is a life-threatening neonatal condition requiring surgical correction. With the advancement of minimally invasive techniques, thoracoscopic repair has emerged as an alternative to conventional open repair; however, concerns regarding operative time and recurrence persist.**Aim:** To compare the clinical outcomes of thoracoscopic versus open repair in patients with congenital diaphragmatic hernia.**Materials and Methods:** This five years prospective comparative study was conducted . A total of 68 patients with CDH were enrolled, of whom 26 underwent thoracoscopic repair and 42 underwent open repair. Data were collected prospectively and analyzed for operative time, duration of mechanical ventilation, ICU stay, hospital stay, postoperative complications, recurrence, and mortality.**Results:** Baseline characteristics were comparable between both groups. The mean operative time was significantly longer in the thoracoscopic group (110 ± 20 minutes vs 85 ± 15 minutes; $p < 0.001$). However, thoracoscopic repair was associated with significantly shorter duration of mechanical ventilation (3.2 ± 1.1 vs 5.1 ± 1.8 days), ICU stay (4.1 ± 1.5 vs 6.8 ± 2.2 days), and hospital stay (8.5 ± 2.3 vs 12.2 ± 3.5 days) ($p < 0.001$). Recurrence was higher in the thoracoscopic group (11.5% vs 4.8%), while wound complications were more common in the open group. Mortality was comparable between both groups.**Conclusion:** Thoracoscopic repair is a safe and effective alternative to open repair in selected CDH patients, offering faster postoperative recovery and reduced morbidity. However, it is associated with longer operative time and a higher risk of recurrence. Careful patient selection and surgical expertise are essential for optimal outcomes.

Keywords: Congenital diaphragmatic hernia, Thoracoscopic repair, Open repair, Pediatric surgery, Minimally invasive surgery

INTRODUCTION

Congenital diaphragmatic hernia (CDH) is a developmental defect of the diaphragm characterized by herniation of abdominal viscera into the thoracic cavity, resulting in pulmonary hypoplasia and persistent pulmonary hypertension of the newborn. It remains a significant cause of neonatal morbidity and mortality, with an estimated incidence of approximately 1 in 2500–4000 live births [1,2].

The pathophysiology of CDH is complex and involves impaired lung development, abnormal pulmonary vasculature, and varying degrees of cardiorespiratory compromise at birth. Despite advances in neonatal intensive care, including gentle ventilation strategies and extracorporeal membrane oxygenation (ECMO), the overall survival remains variable depending on the severity of pulmonary hypoplasia and associated anomalies [3,4].

Surgical repair is a definitive component of CDH management and is typically performed after

preoperative stabilization. Traditionally, CDH repair has been carried out through an open abdominal or thoracic approach, which allows direct visualization and secure closure of the diaphragmatic defect. Open repair remains widely practiced due to its reliability, especially in large defects and hemodynamically unstable patients [5,6].

Over the past two decades, minimally invasive surgery (MIS), particularly thoracoscopic repair, has gained increasing acceptance in pediatric surgical practice. Thoracoscopy offers several advantages, including smaller incisions, reduced postoperative pain, shorter duration of mechanical ventilation, improved cosmetic outcomes, and faster recovery [7,8]. Additionally, enhanced magnification during thoracoscopy may facilitate precise dissection and repair.

However, concerns persist regarding the technical difficulty of thoracoscopic repair, especially in neonates with limited physiological reserve. Several studies have reported longer operative times and a steeper learning curve associated with thoracoscopic procedures [9]. More importantly, higher recurrence rates have been observed in some series, possibly due to tension at the repair site, intracorporeal suturing challenges, and selection bias toward less severe cases [10,11].

Given these considerations, the choice between thoracoscopic and open repair remains a subject of ongoing debate. While thoracoscopic repair may offer short-term advantages, its long-term outcomes, particularly recurrence rates, require further evaluation.
Therefore, the present prospective comparative study was undertaken to evaluate and compare the clinical outcomes of thoracoscopic versus open repair in patients with congenital diaphragmatic hernia at a tertiary care pediatric surgery center.

Patients and Methods

Ethical Considerations
The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from parents or legal guardians prior to inclusion. Patient confidentiality was strictly maintained throughout the study.

Study Design
This was a prospective comparative study. The data were collected from different patient's records. The study was carried out over a period of five years.

Study Population
All consecutive patients diagnosed with congenital diaphragmatic hernia (CDH) and admitted during the study period were prospectively enrolled.

A total of 68 patients were included. They were divided into two groups; Group I (thoracoscopic repair group) including 26 patients. Group II (open repair group) including 42 patients.

Inclusion Criteria
Included in the study were; neonates and infants diagnosed with congenital diaphragmatic hernia.
The study also included those patients who underwent surgical repair (thoracoscopic or open) All hemodynamically stable patients deemed fit for surgery were as well considered.

Exclusion Criteria
Excluded from the study were patients with major congenital anomalies incompatible with survival,
those who expired before surgical intervention and patients with recurrent CDH cases previously operated elsewhere plus those who had incomplete clinical data or loss to follow-up.

Preoperative Management
All patients underwent standardized preoperative stabilization, including; mechanical ventilation using lung-protective strategies, correction of acidosis and electrolyte imbalance, hemodynamic stabilization with inotropic support when required. All patients underwent echocardiographic evaluation for pulmonary hypertension.

Surgical intervention
Surgical techniques were only performed after achieving clinical and hemodynamic stabilization.

Group Allocation
Patients were allocated into the two groups; I and II based on; their hemodynamic stability, size of diaphragmatic defect (assessed radiologically/intraoperatively) as well as the surgeon expertise and preference. However, thoracoscopic repair was preferred in stable patients with smaller defects, while open repair was performed in patients with larger defects or borderline stability

Surgical Technique
- Thoracoscopic Repair

Thoracoscopic repair was performed under general anesthesia with single-lung ventilation where feasible. Patients were placed in the lateral decubitus position. Three ports were inserted, and CO_2 insufflation was used to facilitate visualization. Herniated abdominal contents were reduced into the peritoneal cavity, and the diaphragmatic defect was closed using interrupted non-absorbable sutures. Patch repair was used when primary closure was not feasible.

Open Repair
Open repair was performed via a subcostal abdominal incision. Herniated viscera were reduced, and the diaphragmatic defect was repaired using non-

absorbable sutures, with or without patch placement depending on defect size.

Data Collection
Data were collected prospectively using a standardized structured proforma, including:
demographic details (age, sex), clinical presentation and side of hernia, operative details (type of surgery, operative time), postoperative course parameters plus complications and outcomes.

Outcome Measures
They included; primary outcomes such as; the duration of mechanical ventilation pre and post-surgery, length of hospital stay and also recorded was the recurrence rate. Also reported was the secondary Outcomes including , mean operative time, postoperative complications (wound infection, respiratory complications) plus the overall mortality rate.

Follow-Up
All patients were followed up for a minimum period of 6–12 months postoperatively. Follow-up evaluation involved; clinical examination, chest radiography when indicated plus assessment for recurrence and respiratory function

Statistical Analysis
Data were entered and analyzed using statistical software package (SPSS version 20).
Continuous variables were expressed as mean ± standard deviation (SD).
complete excision of the pedunculated subcutaneous soft-tissue mass arising from the right lower back.

Results

A total of 68 patients with congenital diaphragmatic hernia (CDH) were prospectively enrolled over a period of five years. They were divided into two groups; Group I , n= 26 patients (38.2%) underwent thoracoscopic repair. While group I, n= 42 patients (61.8%) underwent open repair. All patients completed follow-up and were included in the final analysis.

The baseline demographic and clinical characteristics were comparable between both groups. The mean age at surgery was 5.2 ± 2.1 days in the thoracoscopic group and 4.8 ± 2.5 days in the open group. There was a similar gender distribution and predominance of left-sided CDH (~81%) in both groups, with no statistically significant differences.

Table 1: Baseline Demographic and Clinical Characteristics

Parameter	Thoracoscopic (n=26)	Open (n=42)	*p*-value
Mean age (days)	5.2 ± 2.1	4.8 ± 2.5	0.48
Male (%)	15 (57.7%)	24 (57.1%)	0.96
Left-sided CDH	21 (80.8%)	34 (81.0%)	0.98

Table 1 shows no significant difference in baseline characteristics between the two groups.

Analysis of intraoperative parameters revealed that the mean operative time was significantly longer in the thoracoscopic group (110 ± 20 minutes) compared to the open group (85 ± 15 minutes) ($p < 0.001$). However, postoperative recovery was significantly better in the thoracoscopic group. The duration of mechanical ventilation and length of hospital stay were both significantly reduced compared to the open group.

Table 2: Operative and Postoperative Outcomes

Parameter	Thoracoscopic (n=26)	Open (n=42)	*p*-value
Operative time (minutes)	110 ± 20	85 ± 15	<0.001
Ventilation duration (days)	3.2 ± 1.1	5.1 ± 1.8	<0.001
Hospital stay (days)	8.5 ± 2.3	12.2 ± 3.5	<0.001

Table 2 demonstrates that thoracoscopic repair, although time-consuming, results in significantly faster postoperative recovery.

Intraoperative findings showed a comparable distribution of defect sizes between the two groups. Patch repair was more frequently required in the open repair group, although this difference was not statistically significant. Conversion to open surgery was required in a small proportion of thoracoscopic cases.

Table 3: Intraoperative Findings

Parameter	Thoracoscopic (n=26)	Open (n=42)	*p*-value

Small defects	12 (46.2%)	14 (33.3%)	
Moderate defects	10 (38.5%)	18 (42.9%)	0.31
Large defects	4 (15.3%)	10 (23.8%)	
Patch repair required	5 (19.2%)	12 (28.6%)	0.39
Conversion to open	2 (7.7%)	-	-

Table 3 shows similar intraoperative characteristics, with slightly higher patch usage in the open group.

Postoperative respiratory outcomes further favored the thoracoscopic group. Patients who underwent thoracoscopic repair had significantly shorter ICU stay and oxygen dependency duration. Yet, the incidence of pulmonary hypertension was comparable between the groups.

Table 4: Postoperative Respiratory Outcomes

Parameter	Thoracoscopic (n=26)	Open (n=42)	*p*-value
ICU stay (days)	4.1 ± 1.5	6.8 ± 2.2	<0.001
Oxygen requirement (days)	5.3 ± 1.8	8.2 ± 2.6	<0.001
Pulmonary hypertension	6 (23.1%)	11 (26.2%)	0.77

Table 4 demonstrates improved respiratory recovery in the thoracoscopic group.

Postoperative complications were analyzed in details. The recurrence rate was higher in group I (the thoracoscopic group), (11.5%) compared to those of group II (open group), (4.8%), although this difference was not statistically significant. Conversely, wound infections were more common in the open group. The mortality rate was comparable between both groups and was primarily related to underlying pulmonary hypoplasia rather than surgical technique.

Table 5: Postoperative Complications and Outcomes

Parameter	Thoracoscopic (n=26)	Open (n=42)	*p*-value
Recurrence	3 (11.5%)	2 (4.8%)	0.28
Wound infection	1 (3.8%)	6 (14.3%)	0.18
Respiratory complications	4 (15.4%)	9 (21.4%)	0.52
Sepsis	2 (7.7%)	5 (11.9%)	0.58
Mortality	2 (7.7%)	4 (9.5%)	0.79

Table 5 shows that thoracoscopic repair is associated with fewer wound complications but a higher, though statistically insignificant, recurrence rate.

Overall, thoracoscopic repair demonstrated superior postoperative recovery and reduced respiratory morbidity, whereas open repair showed a lower recurrence trend. Mortality remained comparable between the two approaches. The findings of the present study are consistent with current evidence, supporting the role of thoracoscopic repair as an effective alternative to open repair in selected cases. However, careful patient selection, surgeon expertise, and institutional experience remain critical factors in optimizing outcomes. The study has highlighted some key interpretations. They can be simplified as; thoracoscopic repair had led to a better postoperative recovery with lesser needs for assisted ventilation, ICU stay, and also a lesser hospital stay. However, it showed a higher recurrence rate. Nevertheless, mortality rate was highly related to the disease severity rather than the adopted surgical technique

DISCUSSION

Congenital diaphragmatic hernia (CDH) continues to be a major neonatal surgical challenge due to its association with pulmonary hypoplasia and pulmonary hypertension, which significantly influence outcomes [15]. With advances in minimally invasive surgery, thoracoscopic repair has emerged as an alternative to open repair; however, its safety, feasibility, and long-term outcomes remain topics of ongoing debate [1,2].

In the present prospective study, baseline demographic and clinical characteristics were comparable between the thoracoscopic and open repair groups, allowing a reliable comparison of surgical outcomes. Similar comparability has been emphasized in previous studies evaluating CDH repair techniques [3,4].

A key finding of our study was the significantly longer operative time in the thoracoscopic group compared to open repair. This observation is consistent with earlier studies, which attribute prolonged operative duration to the technical complexity of thoracoscopic suturing, limited working space in neonates, and the steep learning curve associated with minimally invasive procedures [2,4,13]. However, with increasing experience and refinement of techniques, operative times have been shown to decrease over time [5].

Despite longer operative time, thoracoscopic repair demonstrated clear advantages in postoperative recovery. In our study, patients undergoing

thoracoscopic repair had significantly shorter duration of mechanical ventilation, ICU stay, and overall hospital stay. These findings are supported by several studies and meta-analyses, which report improved postoperative recovery and reduced morbidity with minimally invasive approaches due to decreased surgical trauma and better preservation of respiratory mechanics [7,9,10,12].

Postoperative respiratory outcomes in our study also favored the thoracoscopic approach, with reduced oxygen dependency and shorter ICU stay. This is particularly relevant in CDH patients, where minimizing ventilatory support is crucial in preventing further lung injury and improving outcomes [11].

With regard to recurrence, our study demonstrated a higher rate in the thoracoscopic group compared to open repair, although the difference was not statistically significant. This trend has been consistently reported in the literature, with multiple studies and meta-analyses indicating higher recurrence rates following thoracoscopic repair [6,9,10]. The increased recurrence is often attributed to technical challenges such as intracorporeal suturing, tension at the repair site, and difficulties in managing larger defects thoracoscopically [6,13]. Careful patient selection and use of patch repair when indicated may help mitigate this risk [8].

In contrast, wound-related complications were more common in the open repair group in our study. This finding aligns with existing literature, where minimally invasive approaches are associated with lower rates of wound infection, reduced postoperative pain, and superior cosmetic outcomes [7,14]. These advantages are particularly important in pediatric populations.

Importantly, the mortality rates were comparable between the two groups in our study, suggesting that the surgical approach does not significantly influence survival. Mortality in CDH is largely determined by the severity of pulmonary hypoplasia, pulmonary hypertension, and associated anomalies rather than the operative technique itself [11,15].

Recent systematic reviews and meta-analyses have further reinforced these findings, concluding that thoracoscopic repair offers improved short-term recovery outcomes but carries a higher risk of recurrence, while open repair remains more reliable for larger defects and unstable patients [9,10,12]. Similarly, single-center experiences have demonstrated that thoracoscopic repair can be safely performed in selected hemodynamically stable patients with favorable anatomy [16].

CONCLUSION

It may be concluded that; thoracoscopic repair of congenital diaphragmatic hernia is a feasible, safe and effective alternative to open repair in carefully selected patients, offering the advantages of shorter ventilation duration and reduced hospital stay. However, it is associated with a relatively higher risk of recurrence and longer operative time. Open repair remains a reliable approach, particularly in complex cases. Optimal outcomes depend on appropriate patient selection and surgical expertise. Extra cohort studies with major numbers may be needed for a more realistic verification of this notion.

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