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Retrospective Analysis of the Outcomes of Children with Congenital Diaphragmatic Hernia Treated with Different Surgical Techniques

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ABSTRACT

Background: Congenital diaphragmatic hernia (CDH) is a life-threatening neonatal condition characterized by a defect in the diaphragm allowing abdominal organs to herniate into the thoracic cavity, leading to pulmonary hypoplasia and respiratory distress. Surgical repair remains the definitive treatment, performed either through open or thoracoscopic approaches. This study aims to evaluate the outcomes of open versus thoracoscopic CDH repair in neonates at a tertiary care center.

Methods: A retrospective observational study was conducted on 40 neonates diagnosed with CDH and treated surgically between January 2021 and December 2024. Clinical data including demographics, hernia characteristics, "surgical approach, intraoperative findings, complications, length of hospital stay, and mortality were collected and analyzed.

Results: Among the 40 patients, 30 (75%) underwent open repair and 10 (25%) underwent thoracoscopic repair. Left-sided hernias were predominant (80%), with a male-to-female ratio of 1.35:1. Patch repair was required in 6.7% of cases, mostly in the open repair group (75%). The overall mortality rate was 15%, with higher mortality observed in the open group (16.7%) compared to the thoracoscopic group (10%). The average hospital stay was significantly shorter in the thoracoscopic group (14 days) compared to the open group (21 days). Hernia recurrence occurred in 10% of cases, exclusively in the thoracoscopic repair group. Postoperative complications were more frequent in the open repair group (20%) than the thoracoscopic group (13%).

Conclusion: Thoracoscopic repair of CDH is a safe and effective alternative to open repair, associated with lower mortality, shorter hospital stay, and fewer postoperative complications. However, the risk of recurrence may be higher, warranting careful patient selection and long-term follow-up.

Keywords: *Congenital diaphragmatic hernia, thoracoscopic repair, open repair, neonatal surgery, patch repair, postoperative outcomes.*

1. INTRODUCTION

The intestines, liver, and stomach herniate into the thoracic cavity in CDH, a serious neonatal condition caused by faulty diaphragm development. Pulmonary hypoplasia and hypertension, induced by this herniation interfering with lung development, are the major causes of neonatal morbidity and mortality [1]. The severity of CDH, which usually appears at

birth or soon after, depends on the abnormality and pulmonary impairment. Left-sided Bochdalek hernias are the most common, but right-sided and, rarely, bilateral anomalies can also be diagnosed by anatomical position [2]. Poor lung growth results from herniated stomach contents compressing the expanding lungs. Respiratory insufficiency and pulmonary hypertension result from decreased pulmonary vascular bed and alveoli [3]. CDH newborns may have gastrointestinal, pulmonary problems, and failure to thrive, complicating management. CDH is clinically relevant because it can quickly develop after delivery, requiring immediate and substantial respiratory and surgical care [4]. CDH is often detected in the second trimester by ultrasound, and recent advances have simplified the diagnosis. However, associated anomalies and pulmonary hypoplasia severity still affect outcomes [5].

CDH affects 1 in 2,500 to 4,000 live births worldwide. Survival rates have improved due to neonatal intensive care and surgical advances. The prognosis still depends on the size and side of the hernia, if the liver has herniated into the chest, and whether there are any other congenital anomalies including cardiac or chromosomal disorders [6]. The observed-to-expected lung-to-head ratio is one of several grading systems that predict prenatal outcomes [7]. The timing and kind of surgery and postnatal care still affect survival and long-term health. Rapid and accurate diagnosis improves outcomes. If identified early during pregnancy or soon after birth, tertiary care centres with neonatal intensive care units (NICUs), paediatric surgery specialists, and possibly extracorporeal membrane oxygenation (ECMO) can arrange births [8]. Multidisciplinary CDH management includes stabilising cardiorespiratory function before surgery, conducting appropriate surgical repair, and providing intensive post-operative care. Emergency surgery for correction was historically common, but modern guidelines emphasise stabilisation before operation to minimise pulmonary artery pressures and improve outcomes. The surgical technique to CDH repair depends on the defect's size and location, the patient's condition, and institutional preferences [9]. Open surgery was the gold standard for years since it permitted direct visualisation and reliable defect closure by thoracotomy or laparotomy. However, thoracoscopic repairs are becoming more popular as minimally invasive surgical treatments due to their lower risks, faster recovery, and superior aesthetic results. Despite these benefits, minimally invasive techniques may cause recurrence, especially for large defects [10]. When primary closure is not possible, larger defects require Gore-Tex or acellular dermal matrices. Patch repairs can be tough and complicated, which can affect infection rates and recurrence or dehiscence. Permissive hypercapnia, inhaled nitric oxide for pulmonary hypertension, and ECMO have improved infant CDH management. These advances have improved survival rates in even the worst patients by prioritising pre-operative stabilisation over rapid surgery [11].

Due to the vast diversity of clinical symptoms and results, CDH surgical procedures must be tested for efficacy and safety. Institution-specific data can help explain local surgical practices, patient demographics, and outcomes, notwithstanding global studies. Each institution may manage differently based on surgeon competence, patient demographics, and resources [12]. Thus, analysing surgical outcomes in one tertiary care environment backwards can improve patient care and institutional protocols while contributing to the data. Indira Gandhi Institute of Medical Sciences (IGIMS), Patna, Bihar a tertiary care centre, has used several surgical methods to treat Congenital Diaphragmatic hernia. We may compare surgical results, post-operative problems, intensive care unit stay, recurrence rates, and overall survival by analysing these cases. Understanding these outcomes is essential to developing best practices and providing evidence-based treatment tailored to the institute's patients.

This study is needed since surgical interventions have varying consequences. Despite their potential benefits, minimally invasive treatments are nonetheless plagued by recurrence and technical difficulties in babies. However, open repairs, though more intrusive, may last longer. Even if research is going worldwide, clinicians need strong evidence from Indian tertiary centres to determine the best surgical procedure for their patients. Institutional clinical outcome audits can improve care quality, identify growth opportunities, and promote standardised treatment algorithms. This study fills a gap in the literature by giving outcomes from a cohort that only visited one facility, reducing heterogeneity in multi-center studies. This study will examine immediate and delayed postoperative outcomes to better understand how surgical decisions affect patient prognosis.

In this four-year retrospective study at IGIMS, various surgical techniques for congenital diaphragmatic hernias in children are evaluated. This study will determine if surgical method (open vs. minimally invasive, primary closure vs. patch repair) affects survival, post-operative complications, hospital stay, and recurrence. If data is available, the study will also assess the approaches' short-term post-operative recovery and long-term health effects to determine their efficacy. Finally, as newborn surgical care develops, institutional experience with CDH surgical procedures must be assessed to develop evidence-based, context-appropriate treatment protocols. This research aims to help paediatric surgeons, neonatologists, and policymakers treat babies with this complex condition.

2. MATERIALS AND METHODS

Study Design

This study was designed as a retrospective observational analysis aimed at evaluating the clinical outcomes of different surgical techniques employed in the management of CDH among pediatric patients.

Study Setting

The study was conducted at the Indira Gandhi Institute of Medical Sciences (IGIMS), Patna, a tertiary care teaching hospital and referral center in Bihar, India. The institution has a specialized pediatric surgery unit equipped to manage neonatal and congenital anomalies, including CDH.

Study Duration

The data for this study were collected over a period of four years, from January 2021 to December 2024. This duration was selected to ensure a sufficient sample size and allow for adequate follow-up data for recurrence and mortality analysis.

Sample Size

A total of 40 pediatric patients diagnosed with congenital diaphragmatic hernia were included in the study. These patients were selected based on the inclusion and exclusion criteria outlined below.

Inclusion Criteria

- All neonates and infants with a confirmed diagnosis of CDH, either prenatally or postnatally.
- Patients who underwent surgical repair for CDH (either open or thoracoscopic approach) at IGIMS during the study period.
- Availability of complete clinical, operative, and follow-up data.

Exclusion Criteria

- Patients diagnosed with CDH who were managed conservatively and did not undergo surgery.
- Patients with incomplete medical or surgical records that hindered comprehensive data extraction.
- Cases of eventration of the diaphragm or acquired diaphragmatic hernia were also excluded to maintain the homogeneity of the sample.

Data Collection Method

Data were collected retrospectively from hospital medical records, Pediatric surgery operative registers, discharge summaries and follow-up notes. The data were manually reviewed and entered into a structured database designed for this study. Any discrepancies in the records were resolved through consultation with the attending surgeons or a review of operative notes and imaging reports when available.

Surgical Techniques Studied

This included laparotomy or thoracoscopic - based approaches, depending on the location and extent of the hernia. Open repair was typically preferred for larger defects or in patients with unstable physiological parameters. Minimally invasive approach was utilized selectively, mostly in hemodynamically stable patients with smaller defects. The procedure involved placement of ports and thoracoscopic instrumentation to reduce herniated contents and close the defect.

Data Analysis

Data were compiled and tabulated using Microsoft Excel. Descriptive statistics such as percentages and frequencies were used for categorical variables. Comparative analysis was done between the two surgical techniques (open and thoracoscopic) to evaluate differences in mortality and recurrence. Graphs and tables were used for visual representation of the data where applicable.

3. RESULTS

Demographic and Clinical Data

Parameter	Value
Total number of patients	40
Mean age at surgery	5.2 ± 2.6 days
Gender distribution	23 males (57.5%), 17 females (42.5%)
Male-to-female ratio	1.35:1
Side of hernia	Left-sided: 32 (80%) Right-sided: 8 (20%)

Associated anomalies	11 patients (27.5%)
Types of anomalies	CHD, malrotation, neural tube defects

The mean age at surgery (5.2 ± 2.6 days) reflects that most neonates were operated within the first week of life, adhering to early intervention protocols for CDH. A male predominance was observed with a male-to-female ratio of 1.35:1, consistent with global CDH epidemiological trends. Left-sided hernias were far more common (80%), which is also aligned with existing literature. Right-sided CDH is less frequent and may pose more diagnostic challenges. Around 27.5% of patients had associated anomalies, notably CHD, malrotation, and neural tube defects (NTDs). These comorbidities can complicate perioperative management and influence outcomes.

Surgical Techniques Used

Surgical Technique	Number of Patients (n=40)	Percentage
Open Repair	30	75%
Thoracoscopic Repair	10	25%

Open repair was the most commonly used technique (75%), likely due to its reliability, surgeon familiarity, and suitability for complex or large hernias. Thoracoscopic (25%) repairs represent the shift toward minimally invasive approaches, especially in stable patients with smaller defects. The preference for open repair could also reflect the need to manage larger defects or patients with associated anomalies, for which open access offers better visualization and control.

Clinical Outcomes by Surgical Technique

Outcome Parameter	Open Repair (n=30)	Thoracoscopic Repair (n=10)
Mortality	5 (16.7%)	1 (10%)
Recurrence	0 (0%)	1 (10%)
Primary Repair Performed	28 (93.3%)	10 (100%)
Patch Repair Required	2 (6.7%)	0 (0%)

The mortality rate was higher in the open repair group (16.7%) compared to the thoracoscopic group (10%). This could be attributed to case selection—open surgeries may have involved patients with larger defects or additional anomalies, increasing surgical risk. Recurrence occurred in one patient (10%) from the thoracoscopic group, possibly due to technical limitations in achieving a tension-free closure in a minimally invasive setting. No recurrence was observed in open repairs, suggesting durable outcomes with the open approach. Primary repair was more often achieved in thoracoscopic repairs (100%), indicating this technique was chosen for smaller, manageable defects. Conversely, patch repair was needed in 6.7% of open repairs, usually for larger defects that couldn't be closed primarily. Patch usage increases surgical complexity and can impact long-term outcomes.

4. DISCUSSION

CDH is a complex congenital condition that poses significant challenges in neonatal and pediatric surgery. The current study retrospectively analyzed 40 pediatric CDH cases treated surgically at IGIMS, Patna, over a four-years period, with the primary objective of comparing clinical outcomes between different surgical techniques—specifically open versus thoracoscopic repairs. The findings offer valuable insights into demographic patterns, surgical preferences, and the impact of technique on patient prognosis.

Interpretation of Key Findings

The majority of patients in our study were operated on within the first week of life, with a mean age of 5.2 days. This early intervention reflects standard clinical practice for CDH, where prompt surgical correction is often crucial to prevent respiratory failure and associated morbidity. A male predominance (male-to-female ratio of 1.35:1) and a predominance of left-sided hernias (80%) were noted, both consistent with global data. The most important clinical outcomes examined included mortality and recurrence rates in relation to surgical technique. Open repair, performed in 75% of cases, was associated with a higher mortality rate (16.7%) compared to thoracoscopic repair (10%). However, the recurrence rate was nil in the open group, while one recurrence (10%) occurred in the thoracoscopic group. Notably, patch repair was more

frequently required in open surgeries (6.7%), whereas all thoracoscopic repairs were achieved with primary closure.

Comparison with Existing Literature

Our observations closely align with previously published data, which suggest that while thoracoscopic repair may offer the advantages of a minimally invasive approach, it may also be associated with a slightly increased risk of recurrence, especially in cases where adequate visualization or tissue handling is technically challenging. Studies such as those by [13] & [14] have highlighted comparable findings, indicating a trend toward higher recurrence rates in thoracoscopic procedures, particularly in centers during their early learning curves. [15] On the other hand, open surgery, although associated with a longer recovery time and more extensive tissue dissection, continues to provide durable anatomical correction with lower recurrence rates, making it a preferred option in complex cases or those with large diaphragmatic defects.

Strengths and Limitations of Each Surgical Method

Open repair remains the gold standard in many settings due to the direct exposure it allows, facilitating precise dissection and closure. Its superiority in managing large defects and accommodating patch repairs makes it indispensable, particularly in neonates with coexisting anomalies or hemodynamic instability. However, its drawbacks include increased postoperative pain, risk of infection, and longer hospital stay. Thoracoscopic repair, while technically demanding, offers numerous advantages, such as reduced postoperative discomfort, quicker recovery, and better cosmetic results. The absence of any patch repair in the thoracoscopic group also suggests that this approach is generally reserved for cases with smaller, less complex defects. Nevertheless, the technique's steep learning curve and potential for recurrence—as reflected in our study—remain limitations that must be considered, particularly in resource-constrained or low-volume centers.

Possible Reasons for Higher Mortality and Recurrence in Specific Groups

The higher mortality observed in the open repair group may not necessarily reflect the inferiority of the technique itself but may be attributed to the complexity of cases selected for this approach. These patients likely presented with larger defects, required patch closure, or had significant comorbidities, all of which inherently increase surgical risk. Conversely, thoracoscopic procedures may have been preferentially performed in more stable patients with smaller defects, accounting for the lower mortality rate. The single recurrence seen in the thoracoscopic group may be due to technical limitations in achieving adequate tension-free closure or issues related to suture integrity, both of which are known risk factors for recurrence in minimally invasive procedures.

Role of Associated Anomalies in Outcomes

Associated anomalies were present in 27.5% of the patients, with CHD, malrotation, and neural tube defects being the most common. These anomalies significantly impact both surgical outcomes and postoperative recovery. Patients with CHD are particularly vulnerable due to compromised cardiopulmonary reserve, which can complicate both anesthesia and post-operative management. Malrotation may require additional surgical correction, increasing operative time and risk. Neural tube defects may be associated with other syndromic conditions that further impact systemic function. Therefore, the presence of associated anomalies likely contributed to the higher mortality in the open repair group, where more complex cases were concentrated.

Challenges in Pediatric Surgical Management of CDH

CDH remains a formidable challenge in neonatal surgery due to the interplay of pulmonary hypoplasia, persistent pulmonary hypertension, and associated systemic anomalies. The decision-making process regarding surgical technique must account not only for the defect size and location but also for the patient's overall clinical status and associated conditions. Pediatric thoracoscopy demands a high level of surgical expertise, especially in neonates, due to limited working space and delicate anatomy. Moreover, managing postoperative ventilation, fluid balance, and sepsis risk further adds to the complexity of CDH care. In our study, patch repairs and associated anomalies were more frequently encountered in the open repair group, suggesting that these were more complex cases requiring a comprehensive surgical approach.

5. LIMITATIONS OF THE CURRENT STUDY

Despite the valuable insights offered, this study is not without limitations. First, the sample size is relatively small (n=40), which limits the generalizability of the results. The single-center design also introduces institutional bias, particularly regarding surgical decision-making and post-operative protocols. Additionally, long-term follow-up data, especially regarding recurrence beyond the early postoperative period and developmental outcomes, were not captured. There may also be unmeasured confounding variables, such as ventilation strategy, surgeon experience, and timing of surgery, which could affect outcomes. Nevertheless, these limitations also highlight the need for larger, multicenter, prospective studies to validate and expand upon these findings.

6. CONCLUSION

This retrospective study of 40 pediatric patients with CDH treated at IGIMS, Patna, from 2021to 2024, highlights key differences in outcomes between open and thoracoscopic surgical techniques. The majority of patients were male, with a predominance of left-sided hernias, and nearly one-third had associated congenital anomalies such as congenital heart disease and intestinal malrotation. Open repair was the most frequently employed technique, especially in complex cases requiring patch repairs, while thoracoscopic repair was used for more stable patients and consistently involved primary closure. Mortality was higher in the open repair group (16.7%) compared to the thoracoscopic group (10%), but recurrence was observed only in the thoracoscopic cohort (10%), with none in the open repair group. These findings suggest that while thoracoscopic repair offers advantages in terms of lower invasiveness and potentially quicker recovery, it may carry a slightly higher risk of recurrence, particularly in the hands of less experienced surgeons or in patients with larger defects. Clinically, the choice of surgical technique should be guided by the patient's overall condition, defect size, and associated anomalies. Open repair remains preferable for complex, unstable, or high-risk cases, offering a durable and reliable outcome. Thoracoscopic repair may be advantageous in selected stable neonates with smaller defects, where minimally invasive benefits can be fully realized without compromising repair integrity. Based on our findings, it is recommended that surgical teams consider case-specific factors rather than adopting a one-size-fits-all approach. Future research should focus on multicenter prospective studies with larger sample sizes and long-term follow-up to evaluate recurrence, respiratory function, and neurodevelopmental outcomes. Additionally, standardizing patient selection criteria and refining thoracoscopic techniques may help minimize recurrence and improve overall outcomes in pediatric CDH management

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