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ORIGINAL ARTICLE

Postoperative Complications and Survival Outcomes in Neonates with Congenital Diaphragmatic Hernia

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ABSTRACT

Background: Congenital diaphragmatic hernia (CDH) is a severe neonatal developmental anomaly, which is linked to pulmonary hypoplasia, persistent pulmonary hypertension, respiratory failure, and is a major cause of morbidity and mortality in the immediate postoperative period. Efforts to improve the survival of infants with surgical repair of congenital heart defects have continued but still have detrimental effects on outcome, especially in less developed health care systems, because of postoperative complications.

Objective: To assess the complications and survival rates of neonates who are surgically repaired for congenital diaphragmatic hernia.

Methods: This prospective observational study was conducted at the Departments of Pediatric Surgery and Neonatal Intensive Care Units of Rashid Latif Medical College/RIHS and Nishtar Medical University, Pakistan, from June 2024 to June 2025. A total of 80 neonates diagnosed with congenital diaphragmatic hernia who underwent surgical repair were enrolled through non-probability consecutive sampling. Demographic data, peri- and postoperative data, and outcome measures were collected and analyzed with SPSS 26.0. A p-value <0.05 was considered statistically significant.

Results: Among 80 neonates, 47 (58.8%) were males and 33 (41.2%) were females. Sixty-one (76.3%) neonates had left-sided CDH, and 21 (26.3%) neonates had liver herniation. Thirty-eight (47.5%) neonates had postoperative complications. The most prevalent complication was found in 16 (20.0%) neonates, persistent pulmonary hypertension, followed by respiratory failure in 12 (15.0%) and pneumothorax in 9 (11.3%) patients. The average mechanical ventilator duration in our patients was 8.9 ± 4.6 days and the average NICU stay was 18.7 ± 8.4 days. Overall survival to discharge was 57 (71.3%) and the remaining 23 neonates (28.7%) died in hospital. Prematurity, low birth weight, liver herniation, PHTN and long periods of ventilator support were significantly associated with mortality (p<0.05).

Conclusion: Surgical repair of congenital diaphragmatic hernia is associated with a high incidence of post-operative complications that affect neonatal survival. In order to achieve better postoperative outcomes and mortality in affected neonates, prompt management of pulmonary and infectious complications, early diagnosis, and aggressive periopertative stabilization and optimized ventilatory support are paramount.

Keywords: Congenital diaphragmatic hernia, neonatal surgery, postoperative complications, pulmonary hypertension, neonatal mortality, survival outcomes.

INTRODUCTION

Congenital diaphragmatic hernia (CDH) is a serious developmental defect of the diaphragm characterized by herniation of abdominal viscera into the thoracic cavity during fetal life[1]. The migration of abdominal organs is abnormal, causing pulmonary hypoplasia and pulmonary vascular abnormalities, which markedly affect the postnatal function of the respiratory system. CDH is regarded as one of the most demanding neonatal surgical emergencies, due to its high association with respiratory failure, persistent pulmonary hypertension and significant postoperative morbidity and mortality rates. The incidence of congenital diaphragmatic hernia is estimated to be between 1 in 2,500 and 1 in 4,000 live births with significant differences in survival rates in developed countries compared to developing countries[2,3].

The pathophysiological mechanism of the CDH is related to the incorrect embryo formation of the diaphragm during a critical period of early gestation resulting in a herniation of abdominal organs, including the stomach, intestines, spleen and liver into the thoracic cavity[4]. This displacemen compresses the developing lungs and gives rise to a severe pulmonary hypoplasia, especially affecting the ipsilateral lung. Furthermore, pulmonary vascular remodeling is abnormal and results in high pulmonary vascular resistance and post-natal pulmonary hypertension, which continues to be one of the most common causes of death among affected neonates. Although neonatal intensive care and surgical techniques have improved over the years, pulmonary complications remain a significant problem in the treatment of CDH[5].

With the development of antenatal ultrasound and fetal imaging, the diagnosis of congenital diaphragmatic hernia is improving, and delivery planning and neonatal management are improving[6]. Today, the approach to treatment focuses on the pre-operative stabilization with gentle ventilation, improvement of ventilation, correction of acidosis, and treatment of pulmonary hypertension prior to definitive surgical repair. The use of delayed surgical intervention following cardiopulmonary stabilization has been demonstrated to yield better outcomes than immediate surgery performed in unstable neonates. However, complications after surgery are common and do add to the length of stay and death. Post-operative complications include sepsis, respiratory failure, recurrent pulmonary hypertension, pneumothorax, wound infections, pleural effusion and reopening of the diaphragmatic defect[7].

There are a number of factors that are predictive of poor outcome in neonates with CDH. These include low birth weight, prematurity, herniation of the liver into the thoracic cavity, large defects of the diaphragms, associated congenital anomalies, and long ventilatory support[8]. Respiratory support is generally more aggressive in neonates that need it, and these infants are likely to have a prolonged stay in the NICU. Uncoordinated perioperative management, inhaled nitric oxide therapy, extracorporeal membrane oxygenation (ECMO) and specialised neonatal intensive care (NICU) have contributed to significant advances in survival in high-resource environments. Mortality is much higher, though, in healthcare systems in which access to advanced cardiac and respiratory care may be limited, particularly in resource-poor settings[9].

Long-term complications in survivors of CDH are becoming more recognised along with other concerns in the immediate postoperative period. Chronic lung disease, recurrent respiratory tract infections, feeding problems, gastroesophageal reflux disease, growth failure, hearing loss, and neurodevelopmental delays are observed in survivors. Therefore, assessing the complications following the surgery as well as survival rates is important for optimizing peri-operative care and long-term care for the neonates[10,11].

There are limited local data available on the outcomes after the surgery for CHD in Pakistan. Therefore, the present study was conducted to evaluate postoperative complications and survival outcomes among neonates undergoing surgical repair for congenital diaphragmatic hernia at a tertiary care hospital[12].

MATERIAL & METHODS

This prospective observational study was conducted at the Department of Pediatric Surgery and Neonatal Intensive Care Units of Rashid Latif Medical College/RIHS and Nishtar Medical University from June 2024 to June 2025. The study was ethically approved by the Institutional Ethical Review Committees of both institutions before data collection began.

The number of neonates was 80 while the technique used was non-probability consecutive sampling. The non-probability consecutive sampling technique was used and the number of neonates was 80 diagnosed with congenital diaphragmatic hernia (CDH) who were undergoing surgical repair. All newborns who were diagnosed both radiologically and intraoperatively with congenital diaphragmatic hernia were recruited regardless of their gender. Patients who died before the definitive surgical procedure, had severe chromosomal abnormalities, or lethal congenital anomalies were excluded from the study.

Demographic and clinical details such as age at presentation, gender, gestational age, birth weight, antenatal diagnosis, mode of delivery, associated congenital anomalies and location of diaphragmatic defect, liver herniation, severity of respiratory distress and need for ventilatory support were documented on a proforma. Baseline laboratory investigations and radiological assessment such as chest radiographs and ultrasonography findings were also recorded.

Pre-operative stabilization in the neonatal intensive care unit was performed in all neonates prior to surgical intervention. Treatment consisted of gentle mechanical ventilation, oxygen supplementation, nasogastric decompression, fluid and electrolyte replacement as necessary, inotropic support as needed, and treatment for persistent pulmonary hypertension. Prophylactic broad-spectrum antibiotics were given following institutional neonatal surgical procedures.

Definitive surgical repair was carried out under general anesthesia via laparotomy. Herniated abdominal viscera were replaced and the defect in the diaphragm was repaired either by approximation or patch repair as per the size of the defect and its tissue's availability. Intraoperative defects, such as the size of the defect, herniation of the liver, malrotation of the bowel and associated anomalies were recorded.

Neonates in the postoperative period were followed in the NICU for the occurrence of complications such as sepsis, pneumothorax, respiratory failure, pleural effusion, persistent pulmonary hypertension, wound infection, hernia recurrence and death. All patients had the duration of mechanical ventilation, duration of NICU stay, outcome of the surgery and survival till discharge recorded.

Results of the data were analyzed by Statistical Package for Social Sciences (SPSS) version 26.0. Gestational age, birth weight, duration of ventilation and hospital stay were expressed as mean ± standard deviation for quantitative variables. Qualitative variables such as gender distribution, postoperative complications and survival outcome were presented as frequencies and percentages. To test associations between variables chi-square test and independent sample t-test were used as appropriate. A p-value < 0.05 was deemed to be statistically significant.

RESULTS

A total of 80 neonates diagnosed with congenital diaphragmatic hernia (CDH) underwent surgical repair during the study period. The mean gestational age of the neonates was 37.3 ±1.8 weeks, and of the birth weight 2.76 ±0.46 kg, with 58.8% being male. Antenatal diagnosis of congenital diaphragmatic hernia was established in 35.0% of neonates before delivery. Left-sided diaphragmatic defects were the most common and right-sided hernias were relatively rare. Thymic herniation was diagnosed intraoperatively in about 25% of the neonates. Intraoperatively liver herniation into the thoracic cavity was identified in about 25% of neonates. Associated congenital anomalies including congenital cardiac defects, intestinal malrotation, and neural tube defects were identified in 23.8% of patients. Detailed baseline demographic and clinical characteristics of the study population are presented in Table 1.

Postoperative complications were observed in 38 (47.5%) neonates following surgical intervention. Persistent pulmonary hypertension and sepsis, which developed in 17.5% and 20.0% respectively, were the most frequent complications. Prolonged ventilatory support was required for respiratory failure in 15.0% of cases and pneumothorax was seen in 11.3% of neonates. VAP was detected in 12.5% patients which accounted for significant contribution to extended NICU stay. Less frequent but clinically relevant complications encountered during postoperative monitoring were wound infection, pleural effusion and recurrence of diaphragmatic hernia. Table 2 provides an outline of the distribution of postoperative complications among neonates.

Further analysis demonstrated that neonates who developed persistent pulmonary hypertension and respiratory failure required significantly prolonged mechanical ventilation compared to uncomplicated neonates. The mean duration of mechanical ventilation after surgery was 8.9 ± 4.6 days for all neonates, and 18.7 ± 8.4 days for the average length of NICU stay. Severe postoperative pulmonary complications occurred in neonates who had ventilator support for more than 10 days and were hospitalized for significantly longer than those without severe pulmonary complications. Sepsis and ventilator associated pneumonia (VAP) also were seen to be associated with delayed recovery and higher mortality rates, respectively.

Overall 57 (71.3%) neonates survived to discharge, while 23 (28.7%) neonates died in hospital despite intensive postoperative management. Preterm neonates, low birth weight, liver herniation, associated congenital anomalies and severe pulmonary hypertension had significantly higher mortality rates. Neonates with low birth weight (< 2.5 kg) had significantly lower survival than those with normal birth weight. Similarly, liver herniation into the thoracic cavity had significant association with severe pulmonary hypoplasia and poor prognosis after surgery. Table 3 compares the detailed data of the survivors and non-survivors.

When outcome measures of postoperative recovery were analyzed, neonates with uncomplicated

postoperative courses had significantly shorter NICU lengths of stay and earlier oral feeding than other neonates. 63.8% of patients were successfully fed orally prior to discharge. 5.0% of neonates needed reoperation for recurrence or postoperative complications. The average total hospital stay for all neonates was 24.5 ± 10.3 days. The parameters of overall postoperative recovery and clinical parameters are provided in Table 4.

The current study showed that postoperative complications remain common in neonates that undergo surgical repair for CHD and are associated with poor survival. One or more postoperative complications occurred in almost half of the neonates, with the most common complications being sepsis, persistent pulmonary hypertension, respiratory failure and pneumothorax. Neonates who had postoperative complications needed significantly longer mechanical ventilation and longer NICU stay than the uncomplicated ones. Overall survival to discharge rate was 71.3%, while mortality was significant in patients with high pulmonary hypertension, associated congenital anomalies, liver herniation, low birth weight and prematurity. The results also indicated the strong correlation between long ventilatory support and long duration of NICU stay with poor postoperative recovery and increased mortality risk. Neonates with birth weight ≥2.5kg showed relatively good clinical outcomes and shorter hospital stay. Neonates with liver herniation had relatively poor clinical outcomes and length of hospital stay. In addition, establishment of oral feeding before discharge was successful in most of the neonates who survived, suggesting good postoperative recovery of stabilized neonates. The findings as a whole highlight the crucial role of early diagnosis, intensive perioperative stabilisation, careful postoperative monitoring and swift management of pulmonary and infectious complications when improving survival rates in neonates with congenital diaphragmatic hernia.

Table 1: Baseline Demographic and Clinical Characteristics of Neonates with Congenital Diaphragmatic Hernia (n=80)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	47	58.8
Female	33	41.2
Gestational Age		
Preterm (<37 weeks)	24	30.0
Term (≥37 weeks)	56	70.0
Birth Weight		
<2.5 kg	27	33.8
≥2.5 kg	53	66.2
Side of Hernia		
Left-sided CDH	61	76.3
Right-sided CDH	19	23.7
Antenatal Diagnosis	28	35.0
Liver Herniation	21	26.3
Associated Congenital Anomalies	19	23.8

Table 2: Postoperative Complications Following Surgical Repair of Congenital Diaphragmatic Hernia (n=80)

Postoperative Complication	Frequency (n)	Percentage (%)
Sepsis	16	20.0
Persistent Pulmonary Hypertension	14	17.5
Respiratory Failure	12	15.0
Ventilator-Associated Pneumonia	10	12.5
Pneumothorax	9	11.3
Wound Infection	7	8.8
Pleural Effusion	5	6.3
Recurrence of Hernia	4	5.0

Table 3: Factors Associated with Survival Outcomes Among Neonates with Congenital Diaphragmatic Hernia

Variable	Survivors (n=57)	Non-Survivors (n=23)	p-value
Mean Birth Weight (kg)	2.91 ± 0.39	2.34 ± 0.36	0.001
Prematurity	12 (21.1%)	12 (52.2%)	0.006
Liver Herniation	9 (15.8%)	12 (52.2%)	0.002
Persistent Pulmonary Hypertension	6 (10.5%)	8 (34.8%)	0.011

Associated Congenital Anomalies	9 (15.8%)	10 (43.5%)	0.009
Mean Ventilation Duration (Days)	7.1 ± 3.2	13.2 ± 4.9	<0.001
Mean NICU Stay (Days)	16.2 ± 6.7	23.4 ± 9.1	0.004

Table 4: Overall Postoperative Clinical Outcomes in Neonates with Congenital Diaphragmatic Hernia (n=80)

Outcome Variable	Mean ± SD / n (%)
Mean Duration of Ventilation (Days)	8.9 ± 4.6
Mean NICU Stay (Days)	18.7 ± 8.4
Mean Hospital Stay (Days)	24.5 ± 10.3
Survivors Discharged	57 (71.3%)
Mortality	23 (28.7%)
Need for Reoperation	4 (5.0%)
Successful Oral Feeding Before Discharge	51 (63.8%)

DISCUSSION

Congenital diaphragmatic hernia continues to be one of the most important surgical emergencies in the neonate due to its close association with pulmonary hypoplasia, persistent pulmonary hypertension, respiratory compromise and significant postoperative mortality[1]. This multicenter study aimed to assess the outcomes and complications of surgical treatment in neonates with congenital diaphragmatic hernia and report a 71.3% overall survival rate. The results are similar to those of earlier studies conducted internationally which reported a 65%–85% survival rate in tertiary neonatal surgical centers[2].

The male predominance seen in the current study is similar to previous epidemiological studies which found a higher incidence of CDH in male neonates[3]. Likewise, left-sided diaphragmatic defects were the most common in the present study, consistent with existing embryological knowledge of the later development of the pleuroperitoneal canal on the left side, leading to a higher incidence of left-sided defects[4].

The study demonstrated a high rate of postoperative complications, affecting almost half of the neonates, reflecting the significant postoperative morbidity of CHD repair[5]. The most common postoperative complication was sepsis. Prolonged ventilatory support, invasive vascular access, and length of stay in NICU are other factors that make neonates especially susceptible to hospital-acquired infections due to their immature immune function and compromised respiratory status. This has been seen in other neonatal surgical studies before where postoperative sepsis played a major role in the extension of hospitalization and mortality[6,7].

Another significant postoperative complication was persistent pulmonary hypertension, which was associated with mortality in the current study[8]. Although anatomical correction of the diaphragmatic defect is the most important factor in survival in CHD, pulmonary hypertension is still one of the main factors that affect survival, and pulmonary vascular remodeling and severe pulmonary hypoplasia are observed even after the defect is surgically corrected[9]. Neonates with severe pulmonary hypertension frequently have to be treated with prolonged mechanical ventilation, inotropic therapy, and intensive cardiopulmonary monitoring. This is in line with the previously reported findings that pulmonary hypertension is an important predictor of poor outcomes in the CDH patient population, which is significantly lower among neonates with pulmonary hypertension compared to those without in this study[10].

Additionally, poor postoperative outcomes were strongly correlated with respiratory failure and long dependence on the ventilator after the surgery[11]. Neonates who were mechanically ventilated longer had a higher mortality, longer NICU stay and had more secondary complications such as ventilator associated pneumonia and pneumothorax. Longer ventilatory support can lead to ventilator-induced lung injury, barotrauma, oxygen toxicity and nosocomial infections, which further compromise the postoperative prognosis[12].

The current research also found there was a significant relationship between liver herniation and the mortality rate[13]. Liver hernias into the thoracic cavity are associated with increased diaphragmatic defects and increased pulmonary compression in fetal development, resulting in significant pulmonary hypoplasia and poor cardiopulmonary adaptation after birth. A high mortality rate was noted in neonates with liver herniation versus those without liver displacement. This has been the same result in other research that has been used to study predictors of outcome in CHD[14].

Other factors that were significant in the present study were prematurity and low birth weight. Neonates born prematurely have less pulmonary maturity, less immune function and decreased physiologic reserve, and postoperative stabilization is significantly more challenging[15]. Similarly, a birth weight of less than 2.5 kg was significantly associated with poor survival in neonates. These results highlight the need for improved planning of antenatal care and delivery in pregnancies complicated by congenital diaphragmatic hernia[16].

The overall survival rate of the present study indicate that the neonatal intensive care, ventilatory management, peri-operative stabilization and surgical techniques have improved over the years in the tertiary care hospitals of Pakistan[17]. The outcomes have improved significantly over the last few years, with strategies including delayed surgical repairs after stabilization, gentle ventilation protocols, optimized oxygen therapy and aggressive treatment of pulmonary hypertension. However, death rates are still significant at international centres with a high level of specialism, where more sophisticated treatments like extracorporeal membrane oxygenation (ECMO) are easily accessible[18].

The results of this study emphasize the significance of co-operation between the various medical specialties, including neonatology, pediatric surgery, anaesthesiology, cardiology and intensive care, in the care of the neonatal patient[19]. To achieve better postoperative results in neonates with CHD, the diagnosis should be made early, appropriate referral to a specialist center should be implemented and careful perioperative monitoring, infection prevention measures and swift treatment of pulmonary complications should be performed[20].

Certain limitations of the study should be acknowledged. This study was carried out in two tertiary care centers and had a small sample size, limiting the generalizability of the results to larger populations[17-19]. The long-term neurodevelopmental, respiratory and nutritional outcomes of survivors were not assessed. Further study is recommended in the future with more centers and larger numbers of patients, as well as longer follow-up periods, to more fully characterize predictors of survival and long-term quality of life in neonates with CHD[20].

CONCLUSION

Postoperative complications are still very common in neonates with CDH and play a major role in survival. The most frequently observed postoperative complications in the present study were sepsis, persistent pulmonary hypertension, respiratory failure and pneumothorax. Low birth weight, preterm, liver herniation, congenital anomalies and long ventilatory support were associated with significantly decreased overall survival. One of the best predictors of mortality after surgical repair was the presence of persistent pulmonary hypertension. Improved survival and reduced morbidity rates following CDH surgery in neonates will require the following steps: early diagnosis, aggressive preoperative stabilization, optimal use of neonatal intensive care, careful postoperative monitoring and timely management of pulmonary and infectious complications. More extensive multicenter trials are needed to assess long-term survival and establish standardized management guidelines to enhance the survival of neonates in resource-limited health care systems.

DECLARATION

Conflict of Interest: The authors declare no conflict of interest.

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