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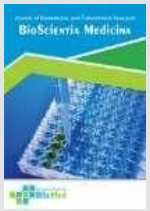

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Early-Onset Neonatal Sepsis and Respiratory Distress in a Newborn with Congenital Diaphragmatic Hernia: A Case Report

Uji Kuatro Nasution[1*], Suwardi[2]

[1]Department of Surgery, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

[2]Department of Pediatric Surgery, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

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***Corresponding author:**
Uji Kuatro Nasution

E-mail address:
uji.kuatro@gmail.com

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A B S T R A C T

Background: A congenital diaphragmatic hernia (CDH) is a severe birth defect where abdominal organs protrude into the chest cavity through a hole in the diaphragm, often leading to respiratory distress. Neonates with CDH are also at an increased risk of developing early-onset neonatal sepsis (EOS) due to impaired lung development and immune function. This case report describes the challenges in managing a newborn with CDH who developed EOS and respiratory distress shortly after birth. **Case presentation:** A 2-day-old infant presented with respiratory distress, including tachypnea, grunting, and retractions. The infant was born full-term via cesarean section with Apgar scores of 5, 7, and 8 at 1, 5, and 10 minutes, respectively. Physical examination revealed decreased breath sounds, dullness to percussion, and decreased fremitus on the left side of the chest. A chest X-ray showed intestinal gas in the left thoracic cavity, confirming the diagnosis of CDH. Laboratory investigations revealed anemia, thrombocytopenia, neutrophilia, lymphocytopenia, and hypocalcemia, suggesting EOS. The infant was admitted to the neonatal high care unit (HCU) and received respiratory support with continuous positive airway pressure (CPAP) and was kept nil per os (NPO). A laparotomy was planned to repair the diaphragmatic hernia. On day 3, the infant developed signs of sepsis and was started on antibiotics. After stabilization, the infant was transferred to the neonatal intensive care unit (NICU) for definitive surgical repair. Post-operatively, the infant received antibiotics, analgesics, and supportive care. **Conclusion:** This case highlights the complexities of managing newborns with CDH and EOS. Early recognition and prompt intervention are crucial for improving outcomes in these critically ill infants.

1. Introduction

Congenital diaphragmatic hernia (CDH) is a significant congenital anomaly characterized by a defect in the diaphragm, the muscular partition separating the thoracic and abdominal cavities. This defect permits the herniation of abdominal viscera into the thoracic cavity, leading to pulmonary hypoplasia, pulmonary hypertension, and potentially life-threatening respiratory distress in newborns. The severity of CDH can vary widely, ranging from mild cases with minimal respiratory compromise to severe cases requiring immediate intervention and prolonged intensive care. The incidence of CDH is estimated to be between 1 in 2,000 and 1 in 5,000 live births, making it a relatively common birth defect. The etiology of CDH is multifactorial, involving both genetic and environmental factors. Several genes have been implicated in the development of CDH, including those involved in diaphragm formation, lung development, and the regulation of cell growth and differentiation. Environmental factors, such as maternal exposure to certain medications or toxins during pregnancy, may also contribute to the risk of CDH.[1,2]

The most common type of CDH is the posterolateral Bochdalek hernia, which accounts for approximately

80-90% of cases. This type of hernia typically occurs on the left side of the diaphragm and involves a defect in the posterolateral region. Other less common types of CDH include the retrosternal Morgagni hernia and diaphragmatic eventration. The clinical presentation of CDH varies depending on the size of the defect, the degree of pulmonary hypoplasia, and the presence of associated anomalies. In severe cases, newborns may present with immediate respiratory distress, including tachypnea, cyanosis, and grunting. Chest examination may reveal decreased breath sounds on the affected side, bowel sounds in the chest, and a scaphoid abdomen. In milder cases, the diagnosis may be delayed, and infants may present with less severe respiratory symptoms or even be asymptomatic.[3,4]

Prenatal diagnosis of CDH is possible through ultrasound examination, which may reveal the presence of abdominal organs in the chest cavity and a mediastinal shift. Prenatal diagnosis allows for early planning and optimization of perinatal care, which can improve outcomes. The management of CDH involves a multidisciplinary approach, including neonatologists, pediatric surgeons, and other specialists. The initial management focuses on stabilizing the newborn's respiratory status and minimizing the risk of complications. This may involve gentle ventilation, administration of surfactant, and, in severe cases, extracorporeal membrane oxygenation (ECMO). Once the infant is stabilized, surgical repair of the diaphragmatic defect is performed. Despite advances in neonatal care, CDH remains associated with significant morbidity and mortality. The most common complications include persistent pulmonary hypertension, respiratory failure, and neurodevelopmental impairment. Early-onset neonatal sepsis (EOS) is another serious complication that can occur in newborns with CDH.[5,6]

EOS is defined as sepsis occurring within the first 72 hours of life. It is a major cause of morbidity and mortality in neonates, particularly those with underlying medical conditions such as CDH. The pathogenesis of EOS in CDH is complex and multifactorial. Several factors contribute to the increased susceptibility to infection in these infants, including; Pulmonary hypoplasia: The underdeveloped lungs in CDH are more susceptible to infection due to decreased alveolar surface area, reduced vascularization, and impaired mucociliary clearance; Impaired immune function: The immune system in infants with CDH may be compromised due to the stress of the underlying condition, the associated respiratory distress, and the potential for malnutrition; Invasive procedures: Neonates with CDH often require invasive procedures such as endotracheal intubation, mechanical ventilation, and central venous catheterization, which can increase the risk of infection; Gut dysbiosis: The altered anatomy and function of the gastrointestinal tract in CDH may lead to gut dysbiosis, which can further impair immune function and increase the risk of infection.[7,8]

The clinical presentation of EOS in newborns with CDH can be subtle and nonspecific, making early diagnosis challenging. Common signs and symptoms include respiratory distress, apnea, bradycardia, temperature instability, lethargy, and feeding intolerance. Laboratory investigations may reveal leukocytosis or leukopenia, thrombocytopenia, elevated C-reactive protein (CRP), and positive blood cultures. The management of EOS in newborns with CDH involves prompt initiation of empiric antibiotics, supportive care, and close monitoring for complications. The choice of antibiotics depends on the suspected pathogens and local antibiograms. Supportive care may include fluid resuscitation, respiratory support, and nutritional management. Prevention of EOS in newborns with CDH is crucial. Strategies to reduce the risk of infection include; Prenatal care: Optimizing maternal health and minimizing the risk of preterm birth can reduce the risk of EOS in newborns with CDH; Aseptic techniques: Strict adherence to aseptic techniques during invasive procedures can minimize the risk of infection; Early enteral feeding: Early initiation of enteral feeding can promote gut colonization with beneficial bacteria and enhance immune function; Probiotics: The use of probiotics may help to modulate

the gut microbiome and reduce the risk of infection. Despite advances in neonatal care, the prognosis for newborns with CDH and EOS remains guarded. The mortality rate for these infants is significantly higher than that for infants with CDH alone. Early diagnosis, prompt intervention, and comprehensive care are essential for improving outcomes in these critically ill neonates.[9,10] This case report describes a newborn with CDH who developed EOS and respiratory distress shortly after birth. The report highlights the challenges in diagnosing and treating these conditions and emphasizes the importance of a multidisciplinary approach to care. By understanding the complex interplay between CDH and EOS, healthcare providers can develop more effective strategies for preventing and treating these complications and improving outcomes for these vulnerable infants.

2. Case Presentation

A two-day-old male infant was referred to our tertiary care hospital from a peripheral center with a primary complaint of progressive respiratory distress. The infant was born at full term via an emergency cesarean section due to fetal distress. The Apgar scores were documented as 5 at 1 minute, 7 at 5 minutes, and 8 at 10 minutes, indicating initial difficulty in establishing adequate respiration and circulation. The birth weight was 2800 grams, falling within the normal range. The mother's prenatal history was unremarkable, with no significant maternal illnesses, exposure to teratogens, or family history of congenital anomalies. The pregnancy was uncomplicated, and the mother received regular prenatal care. Upon arrival at our facility, the infant exhibited clear signs of respiratory distress. The respiratory rate was elevated (tachypnea), and the infant was grunting with each breath, a sign of increased effort to maintain adequate oxygenation. Intercostal retractions, the visible sinking of the skin between the ribs during inhalation, were also observed, further indicating respiratory difficulty. Physical examination of the chest revealed notable asymmetry. Breath sounds were markedly decreased on the left side, suggesting reduced air entry into the left lung. Percussion of the left chest elicited a dull note compared to the resonant note expected over normal lung tissue. Tactile fremitus, the palpable vibration transmitted through the chest wall during vocalization, was also diminished on the left side. These findings were suggestive of decreased lung volume and consolidation on the left side. In contrast, the abdominal examination was unremarkable. The abdomen was soft and non-tender, with no palpable masses or organomegaly. This finding, in conjunction with the respiratory distress and left-sided chest findings, raised suspicion for a congenital diaphragmatic hernia (CDH), where abdominal organs herniate into the chest cavity, compromising lung space and function.

To confirm the clinical suspicion of CDH, a chest X-ray (babygram) was performed. The radiograph revealed the presence of bowel loops and other abdominal viscera within the left hemithorax. The mediastinum was shifted to the right due to the mass effect of the herniated organs. The left hemidiaphragm was poorly visualized, suggesting a diaphragmatic defect. In addition to the chest X-ray, laboratory investigations were conducted to assess the infant's overall health status and to evaluate for potential complications. The complete blood count revealed anemia (hemoglobin 10.3 g/dL), thrombocytopenia (platelet count 18,000/uL), and leukocytosis (white blood cell count 15,000/uL) with a left shift (neutrophilia 78.9%, lymphocytopenia 15.4%). These findings were concerning for early-onset neonatal sepsis (EOS), a serious infection occurring within the first 72 hours of life. Further biochemical analysis showed hypocalcemia (ionized calcium 0.78 mmol/L), which could be attributed to several factors, including sepsis, respiratory distress, and potential hypoparathyroidism secondary to the underlying congenital anomaly.

Given the critical nature of the infant's condition, immediate steps were taken to stabilize the respiratory status and address the suspected sepsis. The infant was admitted to the neonatal high care unit (HCU) for

close monitoring and intensive management. An orogastric tube (OGT) was inserted to decompress the stomach and prevent aspiration, as the presence of abdominal organs in the chest cavity can impair gastrointestinal function. The infant was then placed on continuous positive airway pressure (CPAP) to improve oxygenation and reduce the work of breathing. The initial CPAP settings were a positive end-expiratory pressure (PEEP) of 7 cmH_2O and an inspired oxygen concentration (FiO_2) of 40%. To address the suspected EOS, blood cultures were obtained, and empiric antibiotic therapy was initiated. Ampicillin and gentamicin were chosen as the initial antibiotics to provide broad-spectrum coverage against common neonatal pathogens. The infant was kept nil per os (NPO) to minimize the risk of aspiration and to prepare for potential surgical intervention. Intravenous fluids were administered to maintain hydration and electrolyte balance. Close monitoring of vital signs, including heart rate, respiratory rate, blood pressure, and oxygen saturation, was instituted.

The infant's condition remained critical, with persistent respiratory distress and signs of sepsis. The blood cultures grew Gram-negative bacteria, confirming the diagnosis of EOS. The antibiotic regimen was adjusted accordingly based on the culture and sensitivity results. After a period of stabilization in the HCU, the infant was transferred to the neonatal intensive care unit (NICU) for definitive surgical management. A laparotomy was performed to repair the diaphragmatic hernia. The herniated abdominal organs were carefully reduced back into the abdominal cavity, and the diaphragmatic defect was closed primarily. Following surgery, the infant remained in the NICU for close monitoring and post-operative care. The infant continued to receive antibiotics to treat the ongoing sepsis and analgesics for pain management. The OGT was maintained for gastric decompression, and a rectal tube was placed to monitor for abdominal compartment syndrome, a potential complication after CDH repair. The infant required prolonged mechanical ventilation due to persistent pulmonary hypertension and respiratory insufficiency. Ventilator settings were adjusted gradually to wean the infant off respiratory support. Nutritional support was provided initially through parenteral nutrition and then transitioned to enteral feeding as tolerated. The infant's recovery was further complicated by the development of ventilator-associated pneumonia (VAP), a common complication in infants requiring prolonged mechanical ventilation. VAP was treated with appropriate antibiotics based on culture and sensitivity results. After several weeks of intensive care, the infant's respiratory status gradually improved, and the signs of sepsis resolved. The infant was successfully weaned off mechanical ventilation and transitioned to full enteral feeding. The infant was eventually discharged home with close follow-up by the pediatric surgery and neonatology teams.

The long-term outcomes for infants with CDH and EOS can vary widely. Some infants may experience ongoing respiratory difficulties, neurodevelopmental delays, or growth retardation. Regular follow-up with specialists is essential to monitor for potential complications and to provide appropriate interventions. In this case, the infant was followed closely by the pediatric surgery and neonatology teams. The infant continued to receive respiratory support at home for several months and required ongoing physical and occupational therapy to address developmental delays. Despite these challenges, the infant made steady progress and eventually achieved age-appropriate milestones. This case highlights the complexities involved in managing newborns with CDH and EOS. The combination of these conditions presents a significant challenge, requiring a multidisciplinary approach and intensive care. Early recognition, prompt intervention, and comprehensive care are crucial for improving outcomes in these vulnerable infants.

Table 1. Timeline of disease progression.

Time point	Clinical presentation	Interventions/management	Laboratory findings
Prenatal	- Uncomplicated pregnancy	- Routine prenatal care	-
Birth (Day 0)	- Cesarean section delivery at full term - Apgar scores: 5 (1 min), 7 (5 mins), 8 (10 mins)	- Apgar scores: 5 (1 min), 7 (5 mins), 8 (10 mins)	-
Day 1	- Shortness of breath, weak crying, reduced activity, chest retractions	- Referral to Dr. Oen Hospital	-
Day 2	- Worsening respiratory distress: tachypnea, grunting, retractions - Decreased breath sounds on the left side of the chest - Dull percussion, decreased fremitus on left chest - No abdominal abnormalities	- Babygram: tracheal deviation to the right, intestinal gas in left thoracic cavity - Admission to neonatal HCU - OGT placement - CPAP with PEEP 7 cmH_2O, FiO_2 40% - NPO status - Laparotomy planned	- Anemia (Hb 10.3 g/dL) - Thrombocytopenia (18,000/uL) - Neutrophilia (78.9%) - Lymphocytopenia (15.40%) - Hypocalcemia (ionized calcium 0.78 mmol/L)
Day 3	- Early-onset neonatal sepsis - Moderate respiratory distress	- Blood culture obtained - Antibiotics (ampicillin and gentamicin) - Awaiting NICU availability - Interim management: IV fluids, amino acids, lipids, platelet transfusion	- Blood cultures pending
Post-NICU transfer	- Successful laparotomy for hernia repair	- Post-operative care in NICU: antibiotics, analgesics, OGT maintenance, rectal tube placement, muscle relaxants	- Improving blood counts and calcium levels

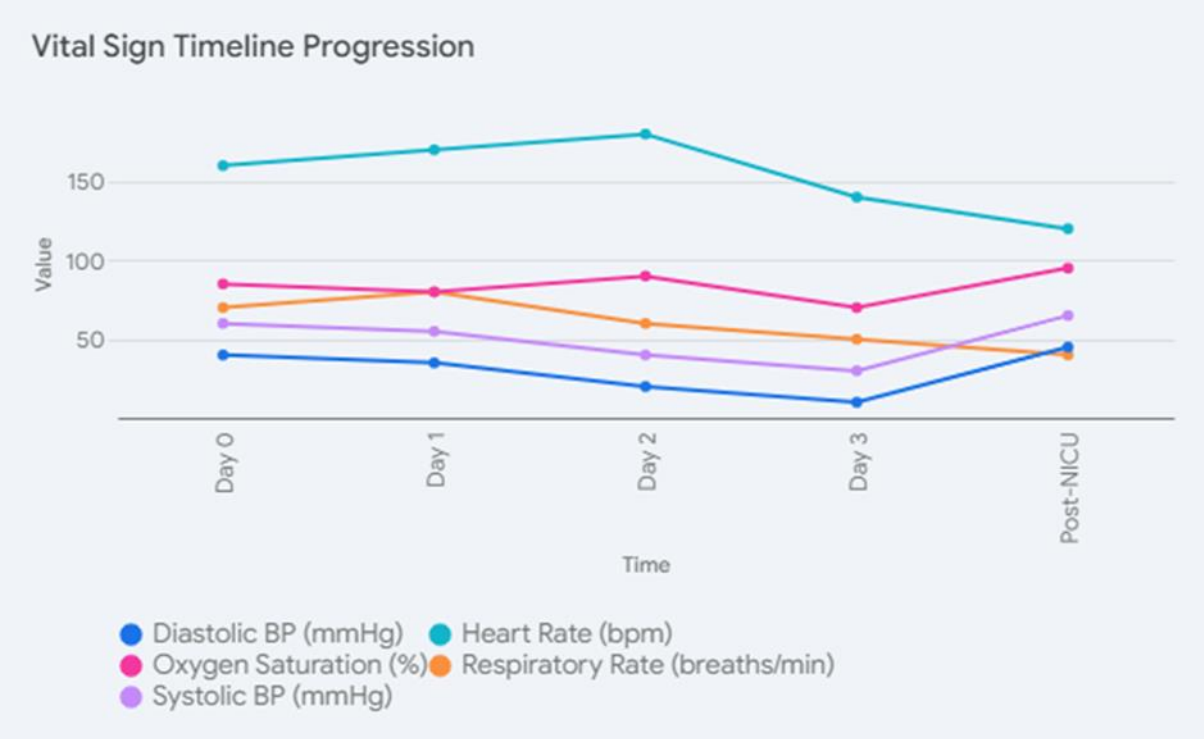

Figure 1. Vital sign timeline progression.

3. Discussion

Congenital diaphragmatic hernia (CDH) is a birth defect that arises from an error in the formation of the diaphragm, the critical muscle that separates the chest cavity (thorax) from the abdominal cavity. This malformation results in a hole or opening in the diaphragm, allowing abdominal organs like the intestines, stomach, liver, and even the spleen to migrate upwards into the chest. The timing and size of this herniation significantly impact the severity of the condition. Early and extensive herniation can severely restrict lung development, leading to a condition known as pulmonary hypoplasia. Pulmonary hypoplasia is a hallmark of CDH and a major determinant of its severity. It's characterized by underdeveloped lungs with fewer alveoli (the tiny air sacs responsible for gas exchange), reduced branching of the airways, and abnormal blood vessel development in the lungs. These structural abnormalities significantly impair the lungs' ability to function effectively, leading to difficulties in breathing and oxygen exchange. The severity of pulmonary hypoplasia is directly related to the timing and extent of the diaphragmatic defect. Early herniation of abdominal organs into the chest cavity during fetal development can severely compress the developing lungs, preventing them from growing and maturing properly. The degree of lung compression and the resulting pulmonary hypoplasia can vary widely, leading to a spectrum of clinical presentations in newborns with CDH. In addition to pulmonary hypoplasia, infants with CDH often develop persistent pulmonary hypertension in the newborn (PPHN). This condition is characterized by high blood pressure in the lungs, which can further impair oxygenation and lead to respiratory failure. PPHN in CDH is multifactorial, arising from a combination of pulmonary hypoplasia, abnormal pulmonary vascular development, and the presence of vasoactive substances in the circulation. The clinical presentation of CDH is highly variable, ranging from mild cases with minimal respiratory compromise to severe cases requiring immediate intervention and prolonged intensive care. The severity of the presentation is primarily determined by the degree of pulmonary hypoplasia and the associated pulmonary hypertension. In severe cases, newborns may exhibit respiratory distress immediately after birth. They may breathe rapidly (tachypnea), have a bluish discoloration of the skin (cyanosis) due to inadequate oxygenation, and grunt with each breath as they attempt to keep their lungs inflated. The chest may appear asymmetrical, with the affected side appearing smaller and less mobile due to the presence of abdominal organs. Breath sounds may be decreased or absent on the affected side, and bowel sounds may be heard in the chest. The abdomen may be scaphoid (sunken) due to the displacement of organs into the chest. In less severe cases, the infant may initially appear stable with minimal or no respiratory distress. However, as the infant grows and the demand for oxygen increases, respiratory difficulties may become apparent. These infants may present with tachypnea, increased work of breathing, and poor feeding. The diagnosis of CDH can be made prenatally or postnatally. Prenatal diagnosis is typically achieved through ultrasound examination during the second or third trimester of pregnancy. Ultrasound may reveal the presence of abdominal organs in the chest cavity, a mediastinal shift, and a small or absent stomach bubble in the abdomen. Prenatal diagnosis allows for early planning and optimization of perinatal care, which can improve outcomes. Postnatal diagnosis is usually made based on the clinical presentation and chest X-ray findings. The chest X-ray typically shows the presence of bowel loops or other abdominal organs in the chest cavity, a mediastinal shift, and a poorly defined diaphragm. Bochdalek Hernia is the most common type of CDH, accounting for approximately 80-90% of cases. It involves a defect in the posterolateral region of the diaphragm, typically on the left side. Morgagni Hernia is a less common type of CDH, accounting for about 2-5% of cases. It involves a defect in the anterior part of the diaphragm, usually on the right side. Central Hernia is a rare type of CDH, involving a defect in the central portion of the

diaphragm. Diaphragmatic Eventration is a condition where one or both sides of the diaphragm are abnormally thin and weak, leading to elevation into the chest cavity. CDH is often associated with other congenital anomalies, which can further complicate management and impact outcomes. These associated anomalies may involve the cardiovascular, gastrointestinal, genitourinary, or musculoskeletal systems. Chromosomal abnormalities, such as trisomy 18 and trisomy 21, are also more common in infants with CDH. As mentioned earlier, PPHN is a common complication of CDH, further impairing oxygenation and increasing the risk of respiratory failure. The altered anatomy and function of the gastrointestinal tract in CDH can predispose to GERD, which can lead to aspiration and respiratory complications. Infants with CDH are at increased risk for neurodevelopmental impairment, which may manifest as delays in motor, cognitive, or language development. The increased metabolic demands and potential feeding difficulties associated with CDH can lead to growth retardation.[11,12]

Early-onset neonatal sepsis (EOS) is a grave and potentially life-threatening infection that manifests within the first 72 hours of a newborn's life. This condition poses a significant risk to all neonates, but its impact is particularly pronounced in those grappling with underlying medical conditions, such as congenital diaphragmatic hernia (CDH). The presence of CDH amplifies the vulnerability to EOS, creating a complex interplay of factors that demand vigilant attention and proactive management. Pulmonary hypoplasia, a hallmark of CDH, significantly increases the susceptibility to EOS. The underdeveloped lungs, characterized by a reduced number of alveoli, diminished vascularization, and impaired ciliary function, create an environment conducive to bacterial colonization and proliferation. The reduced alveolar surface area limits the lungs' capacity for gas exchange, hindering the efficient clearance of inhaled pathogens. Additionally, the compromised pulmonary vasculature can lead to ventilation-perfusion mismatch, further compromising oxygenation and creating areas of relative hypoxia that favor bacterial growth. The decreased number of cilia, the microscopic hair-like projections that propel mucus and trapped pathogens out of the airways, further impairs the lungs' ability to defend against infection. The physiological stress imposed by CDH and the accompanying respiratory distress can significantly impact the developing immune system of a neonate. The body's response to stress involves the release of hormones like cortisol, which, while essential for survival, can also suppress immune function. This immunosuppressive effect renders the infant more susceptible to infections, including EOS. Furthermore, infants with CDH may experience feeding difficulties and increased metabolic demands due to their underlying condition. This can lead to malnutrition, which further compromises immune function and increases the risk of infection. The management of CDH often necessitates invasive procedures, such as endotracheal intubation, mechanical ventilation, and central venous catheterization. While these interventions are crucial for supporting the infant's respiratory and circulatory function, they also carry an inherent risk of infection. The disruption of the skin and mucosal barriers during these procedures creates potential portals of entry for pathogens. Moreover, the presence of foreign bodies, such as endotracheal tubes and catheters, can serve as a breeding ground for bacteria, facilitating the formation of biofilms that are resistant to antibiotics and host defenses. The altered anatomy and function of the gastrointestinal tract in CDH can disrupt the delicate balance of the gut microbiota, leading to a state of dysbiosis. The gut microbiota plays a pivotal role in immune development and function, influencing the maturation of immune cells and the production of antimicrobial peptides. Disruptions in the gut microbiota can impair immune responses, increasing the risk of systemic infections like EOS. The clinical presentation of EOS in newborns with CDH can be subtle and easily overlooked, as it often overlaps with the symptoms of CDH itself. This diagnostic challenge necessitates a high index of suspicion and a

comprehensive approach to assessment. Vigilant monitoring for signs of infection, such as worsening respiratory distress, apnea, bradycardia, temperature instability, lethargy, and feeding intolerance, is crucial. Laboratory investigations, including blood cultures, complete blood count, and inflammatory markers, are essential for confirming the diagnosis and guiding antibiotic therapy. The management of EOS in neonates with CDH requires a multi-pronged approach. Prompt initiation of empiric antibiotic therapy is paramount, targeting the most likely pathogens based on the clinical presentation and local epidemiology. Supportive care, including fluid resuscitation, respiratory support, and nutritional management, is also critical for optimizing the infant's chances of recovery. Prevention of EOS in this vulnerable population is of utmost importance. Strategies to minimize the risk of infection include meticulous prenatal care, strict adherence to aseptic techniques during invasive procedures, early initiation of enteral feeding to promote gut colonization with beneficial bacteria, and the potential use of probiotics to modulate the gut microbiome. Despite advances in neonatal care, EOS remains a significant cause of morbidity and mortality in infants with CDH. The complex interplay of factors contributing to EOS in this population necessitates ongoing research to develop more effective preventive and treatment strategies. Future studies should focus on identifying specific risk factors for EOS in CDH, developing targeted interventions to reduce the incidence of infection, and optimizing antibiotic therapy and supportive care for these critically ill infants. The successful management of EOS in newborns with CDH requires a collaborative effort between neonatologists, pediatric surgeons, infectious disease specialists, and other healthcare professionals. By understanding the intricate pathophysiology of EOS in CDH and implementing evidence-based preventive and treatment strategies, we can strive to improve outcomes and enhance the quality of life for these vulnerable infants and their families.[13,14]

The clinical presentation of early-onset neonatal sepsis (EOS) in newborns with congenital diaphragmatic hernia (CDH) is often a diagnostic tightrope walk, fraught with challenges due to its subtle and nonspecific nature. The symptoms of EOS can easily masquerade as manifestations of the underlying CDH, making early detection a formidable task that demands a high index of suspicion and meticulous clinical acumen. The respiratory system often bears the brunt of EOS in infants with CDH. Worsening or persistent respiratory distress, despite appropriate management of the CDH, can be a red flag. This may manifest as an increase in the respiratory rate (tachypnea), audible grunting sounds with each breath, retractions of the chest wall muscles, or a drop in oxygen saturation levels. Apnea, or temporary cessation of breathing, can also be a sinister sign of sepsis in neonates. Cardiovascular manifestations of EOS can include bradycardia, a slowing of the heart rate. This can be a concerning sign, as it may indicate impaired cardiac function or systemic inflammation. Temperature instability, either in the form of hypothermia (low body temperature) or hyperthermia (high body temperature), can also signal the presence of infection. Subtle changes in the infant's behavior and neurological status can also provide valuable clues. Lethargy, decreased activity, or irritability may indicate a systemic illness. Feeding intolerance, manifested as poor feeding or vomiting, can also be associated with sepsis. While the clinical presentation can raise suspicion for EOS, laboratory investigations are crucial for confirming the diagnosis and guiding appropriate management. A complete blood count (CBC) can reveal several abnormalities suggestive of infection. Leukocytosis, an elevated white blood cell count, is a common finding in sepsis, reflecting the body's attempt to fight off the invading pathogens. However, leukopenia, a low white blood cell count, can also occur, particularly in overwhelming sepsis or in infants with compromised immune systems. Thrombocytopenia, a decrease in platelet count, is another frequent finding in EOS. This can be

attributed to several factors, including increased consumption of platelets during the inflammatory response, decreased production of platelets in the bone marrow, and sepsis-induced disseminated intravascular coagulation (DIC). Examination of the white blood cell differential can provide further insights into the nature of the infection. A left shift, characterized by an increased proportion of immature neutrophils (bands), suggests an acute bacterial infection. Lymphopenia, a decrease in lymphocyte count, can also be observed in sepsis, reflecting the impact of the infection on the adaptive immune system. Elevated C-reactive protein (CRP), a marker of inflammation, is another valuable indicator of EOS. CRP levels rise rapidly in response to infection and can be used to monitor the response to treatment. Blood cultures remain the gold standard for diagnosing EOS. Positive blood cultures identify the specific pathogen responsible for the infection, allowing for targeted antibiotic therapy. However, blood cultures can take several days to yield results, and empiric antibiotic therapy is often initiated before the results are available. Early recognition and prompt intervention are paramount in the management of EOS in newborns with CDH. The combination of these conditions can rapidly deteriorate, leading to multi-organ dysfunction and death. A high index of suspicion, coupled with careful clinical assessment and timely laboratory investigations, is crucial for early diagnosis. Once EOS is suspected, empiric antibiotic therapy should be initiated without delay. The choice of antibiotics should be based on the most likely pathogens and local antibiograms. Supportive care, including fluid resuscitation, respiratory support, and nutritional management, is also essential for optimizing the infant's chances of recovery. The management of EOS in newborns with CDH requires a multidisciplinary approach involving neonatologists, pediatric surgeons, infectious disease specialists, and other healthcare professionals. Close collaboration and communication among the team members are essential for ensuring optimal care and improving outcomes. The successful management of EOS in this vulnerable population hinges on early recognition, prompt intervention, and comprehensive care. By understanding the intricate pathophysiology of EOS in CDH and implementing evidence-based preventive and treatment strategies, we can strive to improve outcomes and enhance the quality of life for these infants and their families.[15,16]

The management of a neonate with both congenital diaphragmatic hernia (CDH) and early-onset neonatal sepsis (EOS) is a multifaceted endeavor, demanding a multidisciplinary approach, meticulous attention to detail, and the ability to adapt to evolving clinical scenarios. The overarching goal is to stabilize the infant's condition, address the underlying CDH and sepsis, and provide comprehensive supportive care to optimize the chances of recovery. The first priority in managing a neonate with CDH and EOS is to stabilize the infant's respiratory and hemodynamic status. The presence of abdominal organs in the chest cavity can severely compromise lung function, leading to respiratory distress and hypoxia. In this case, the infant presented with significant respiratory distress, necessitating immediate intervention. Continuous positive airway pressure (CPAP) was initiated to improve oxygenation and reduce the work of breathing. CPAP provides a continuous flow of air at a slightly higher pressure than atmospheric pressure, helping to keep the alveoli open and improve gas exchange. The infant was also kept nil per os (NPO) to prevent aspiration, as the presence of abdominal organs in the chest can impair gastrointestinal function and increase the risk of aspiration pneumonia. Intravenous fluids and electrolyte replacement were administered to maintain adequate hydration and correct any electrolyte imbalances. Close monitoring of vital signs, including heart rate, respiratory rate, blood pressure, and oxygen saturation, was essential to assess the infant's response to therapy and to detect any signs of deterioration. Early-onset neonatal sepsis is a medical emergency that requires prompt and aggressive treatment. In this case, the suspicion of EOS was high based on the clinical presentation and laboratory

findings. Empiric antibiotic therapy was initiated without delay, even before the blood culture results were available. The initial choice of antibiotics, ampicillin, and gentamicin, provided broad-spectrum coverage against the most common neonatal pathogens. Once the blood culture results confirmed the presence of Gram-negative bacteria, the antibiotic regimen was tailored to the specific organism identified. The duration of antibiotic therapy was guided by the clinical response and laboratory parameters. The timing of surgical repair of the diaphragmatic hernia is a crucial decision in the management of neonates with CDH. Early repair may be advocated to minimize further lung compression and improve respiratory function. However, in infants with significant comorbidities, such as EOS or severe pulmonary hypertension, a delayed approach may be preferred to allow for stabilization of the infant's condition and optimization of pulmonary function. In this case, the presence of EOS and the infant's critical condition necessitated a delayed approach to surgery. The infant was closely monitored in the neonatal intensive care unit (NICU), and surgical repair was performed once the sepsis was controlled and the infant's overall condition had improved. The post-operative period is a critical phase in the recovery of infants with CDH. The infant may require prolonged mechanical ventilation due to persistent pulmonary hypertension and respiratory insufficiency. Weaning from mechanical ventilation is a gradual process that requires careful titration of ventilator settings and close monitoring of respiratory parameters. The development of ventilator-associated pneumonia (VAP) is a common complication in infants requiring prolonged mechanical ventilation, particularly those with underlying lung disease. Preventive measures, such as elevating the head of the bed, maintaining oral hygiene, and using aseptic techniques during suctioning, are crucial for reducing the risk of VAP. In this case, the infant developed VAP, which was treated with appropriate antibiotics based on culture and sensitivity results. Nutritional support is another vital aspect of post-operative care. Infants with CDH may have feeding difficulties due to the altered anatomy and function of the gastrointestinal tract. Initially, parenteral nutrition may be necessary to meet the infant's nutritional needs. As the infant's condition improves, enteral feeding can be gradually introduced and advanced as tolerated. The recovery of an infant with CDH and EOS is a long and arduous journey that requires the concerted efforts of a multidisciplinary team. Neonatologists, pediatric surgeons, infectious disease specialists, respiratory therapists, nurses, and other healthcare professionals play a crucial role in providing comprehensive care and support to the infant and family. The long-term outcomes for infants with CDH and EOS can vary widely. Some infants may experience ongoing respiratory difficulties, neurodevelopmental delays, or growth retardation. Regular follow-up with specialists is essential to monitor for potential complications and to provide appropriate interventions. In this case, the infant required prolonged hospitalization and intensive care. The infant was eventually discharged home with ongoing respiratory support and developmental therapy. Despite the initial challenges, the infant made steady progress over time and was able to achieve age-appropriate milestones.[17,18]

The long-term prognosis for infants facing the dual challenges of congenital diaphragmatic hernia (CDH) and early-onset neonatal sepsis (EOS) is a complex tapestry woven with threads of uncertainty and hope. The path to recovery is often long and arduous, and the ultimate outcomes can vary widely depending on a multitude of factors. The size and location of the diaphragmatic defect, the degree of pulmonary hypoplasia, and the presence of associated anomalies all contribute to the overall severity of CDH. Infants with severe CDH and significant pulmonary hypoplasia face a higher risk of long-term complications and mortality. The extent of lung underdevelopment is a critical determinant of prognosis. Severe pulmonary hypoplasia can lead to persistent pulmonary hypertension, chronic respiratory insufficiency, and the need for prolonged respiratory support. The presence of other congenital

anomalies, such as cardiac defects or chromosomal abnormalities, can further complicate management and impact long-term outcomes. Early diagnosis and timely intervention are crucial for improving outcomes in infants with CDH and EOS. Delays in diagnosis or treatment can lead to worsening respiratory distress, sepsis-related complications, and increased mortality. The post-operative period is a critical phase in the recovery of infants with CDH. Complications such as persistent pulmonary hypertension, ventilator-associated pneumonia, and feeding difficulties can impact long-term outcomes. Chronic respiratory insufficiency, recurrent respiratory infections, and reactive airway disease are common long-term complications of CDH. Some infants may require ongoing respiratory support, such as oxygen therapy or home ventilation. Infants with CDH are at increased risk for neurodevelopmental delays, which may manifest as difficulties with motor skills, cognitive function, or language development. These delays may be attributed to factors such as hypoxia, prolonged hospitalization, and exposure to medications. The increased metabolic demands and potential feeding difficulties associated with CDH can lead to growth retardation. Some infants may require nutritional supplementation or specialized feeding interventions to achieve adequate growth. Gastroesophageal reflux disease (GERD) and feeding difficulties are common in infants with CDH. These complications can impact growth and development and may require ongoing management. Infants with CDH are at increased risk for hearing impairment, which may be due to factors such as hypoxia or exposure to ototoxic medications. Regular hearing screenings are recommended to detect any hearing loss early and initiate appropriate interventions. In the case presented, the infant faced a challenging course, requiring prolonged hospitalization and intensive care. The combination of CDH and EOS posed a significant threat to the infant's survival and long-term well-being. However, with timely diagnosis, aggressive treatment, and comprehensive supportive care, the infant was able to overcome these initial hurdles. The infant required prolonged mechanical ventilation and experienced the complication of ventilator-associated pneumonia, highlighting the ongoing challenges in managing these complex cases. However, with careful titration of ventilator settings, appropriate antibiotic therapy, and meticulous supportive care, the infant was successfully weaned off mechanical ventilation and recovered from the infection. The infant also faced developmental delays, likely related to the underlying CDH and the prolonged hospitalization. However, with ongoing physical and occupational therapy, the infant made steady progress and eventually achieved age-appropriate milestones. This case demonstrates the resilience of infants with CDH and EOS and the potential for positive long-term outcomes with appropriate care. While the road to recovery may be long and fraught with challenges, many infants with CDH and EOS can go on to lead fulfilling lives. Regular follow-up with specialists is essential for infants with CDH and EOS. This allows for ongoing monitoring of respiratory function, growth and development, and any potential complications. Early detection and intervention for any emerging issues can significantly improve long-term outcomes. Advances in neonatal care, including improved surgical techniques, enhanced respiratory support, and refined antibiotic therapy, have led to significant improvements in the survival and long-term outcomes of infants with CDH and EOS. Ongoing research is focused on developing new and innovative approaches to the management of these conditions, with the goal of further reducing morbidity and mortality and improving the quality of life for these infants and their families.[19,20]

4. Conclusion

This case report underscores the critical importance of early recognition and prompt intervention in managing newborns with CDH and EOS. The combination of these conditions presents a formidable challenge, demanding a multidisciplinary approach and meticulous attention to detail. The successful outcome in this case highlights the potential for positive outcomes, even in the face of

significant adversity. Continued research and collaboration among healthcare professionals are essential to further refine our understanding and management of these complex cases, ultimately improving the lives of these vulnerable infants and their families.

5. References

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