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Air Transportation Impact on a Late Preterm Neonate

Sheng-Ping Li; Po-Chang Hsu; Chuang-Yen Huang; Po-Wei Wu; Hung-Hsiang Fang

BACKGROUND: Neonatal air transportation is a crucial means of moving critically ill or sick neonates to specialized neonatal intensive care units or medical centers for consultation, regardless of distance or geographical limits. Proper preparation and consideration of air transport can help alleviate medical emergencies and ensure safe delivery. However, crewmembers and neonates may face stress during transportation. To date, there are few studies on neonatal air transportation in Taiwan.

CASE REPORT: We present the case of a late preterm neonate born with neonatal respiratory distress syndrome and polycythemia, who was also diagnosed with patent ductus arteriosus and mild pulmonary arterial hypertension on echocardiography. Due to disease progression, the neonate underwent endotracheal intubation and was subsequently transported to a medical center in Taiwan via a rotary-wing aircraft at 3 d of age. During takeoff and landing, a temporary oxygen desaturation event occurred. The physiological changes in these patients have seldom been discussed. This case emphasizes the important considerations of neonatal transport in Taiwan.

DISCUSSION: The air transport process could be influenced by both the patient's medical condition and environmental factors. In preterm infants with cardiopulmonary conditions, thorough assessment is necessary for ensuring safe transportation.

KEYWORDS: neonatal air transportation, respiratory distress syndrome, polycythemia, preterm infants.

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Premature infants and other neonates are particularly vulnerable to medical and/or surgical issues and may require urgent evaluation or management. However, providing appropriate medical care for critically ill or sick neonates can be challenging, particularly on offshore islands, where access to specialized medical facilities may be limited. Neonatal air transportation offers a means of safely shifting neonates to neonatal intensive care units or specialty consultation centers, regardless of distance or geographical barriers. Whether using rotary-wing or fixed-wing air ambulances, neonatal transport presents unique challenges for aircrews and neonates, including hypoxia, hypobaria, noise, vibration, temperature changes, and reduced humidity.[3,9] Both crewmembers and neonates may face stresses in the air. Adequate preparation and consideration by hospital staff and crewmembers could help mitigate the effects of aeromedical stressors and ensure safe transportation.

Penghu is located approximately 50 km west of the main island of Taiwan. Three district hospitals provide local medical services. The Tri-Service General Hospital, Penghu Branch, is the main hospital for women and children. Owing to geographical barriers, Penghu is in a relatively isolated area. When emergencies occur, medical evacuation can be a big challenge. However, studies focusing on neonatal transportation are relatively rare. This air transportation case report highlights the essential considerations of neonatal transportation in Taiwan.

CASE REPORT

Written informed consent for all subsequent patient information and clinical images was provided by the patient's legal guardians. Signed informed consent was obtained from the patient's parents in accordance with the Institutional Review

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Board of the Tri-Service General Hospital. The ethics committee approved this study (TSGHIRB No.: A202315041).

A late preterm infant was born to a pregnant woman at 36-6/7 wk gestation via cesarean section due to a history of previous cesarean section and preterm labor. The newborn had Apgar scores of 8 and 9 at 1 and 5 min, respectively. Shortly after birth, the patient exhibited dyspnea, subcostal retraction, and cyanosis. A chest radiograph showed a grade II–III reticulogranular pattern (**Fig. 1**). Therefore, the newborn was transferred to a neonatal intensive care unit, where continuous positive airway pressure was administered. In addition, blood test results showed high levels of hemoglobin (Hb; 23.1 $g \cdot dL^{-1}$) and hematocrit (Hct; 69.2%), indicating polycythemia. During hospitalization, Hb and Hct levels increased to 24.2 $g \cdot dL^{-1}$ and 70.0%, respectively (**Fig. 2**). Echocardiography revealed patent ductus arteriosus and mild pulmonary arterial hypertension. Despite adjustments to the ventilation strategy, the newborn's respiratory distress persisted and gradually worsened. For managing polycythemia, the physician provided adequate hydration and performed a partial exchange transfusion with 20 ml of 0.9% saline. However, by the third day of life, the newborn's respiratory condition deteriorated further, and endotracheal intubation was necessary to maintain adequate oxygenation. Since the newborn's symptoms persisted and continued to worsen, the medical team determined the need for advanced cardiopulmonary assessment. In response, the attending physician contacted the National Aeromedical Approval Center to request air transportation for the baby. To ensure safe and comfortable transfer, the necessary equipment was prepared, including a transport incubator, respiratory support system, T-piece resuscitator, portable oxygen cylinders, vital sign monitors, and syringe pumps. Before takeoff, a qualified emergency medical technician and medical staff conducted a clinical handover using the Identify, Situation, Background, Assessment, and Recommendation protocol. The rotary-wing aircraft flew at an altitude of 1000 ft (304.8 m) during transport, facing wind from the northeast at a speed of approximately 20–30 mph. Noise and vibration appeared to have an impact on the medical approach and the patient's condition during the trip. During the patient's journey, the vibrations experienced can potentially lead to physiological responses, such as an increase in heart rate and respiratory rate. These vibrations could induce temporary changes in vital signs, which is an important consideration for the medical team. Prolonged exposure to such vibrations might contribute to patient fatigue, further underscoring the significance of managing this aspect. Moreover, it is worth noting that the presence of pronounced noise and vibration poses challenges not only to patients but also to medical practitioners. These adverse conditions could hinder the ability to conduct precise auscultation, which is a fundamental aspect of accurate medical assessment. Physicians and technicians may find it challenging to discern subtle sounds, impacting the overall quality of their diagnostic procedures. Additionally, the patient's oxygen saturation temporarily decreased to approximately 80% during the takeoff and landing of the rotary-wing aircraft. This flight took 37 min. Upon arrival, an ambulance was ready for subsequent transportation. The patient was transferred to a medical center and received specialized care. After 1-mo follow-up, the patient was discharged from the hospital.

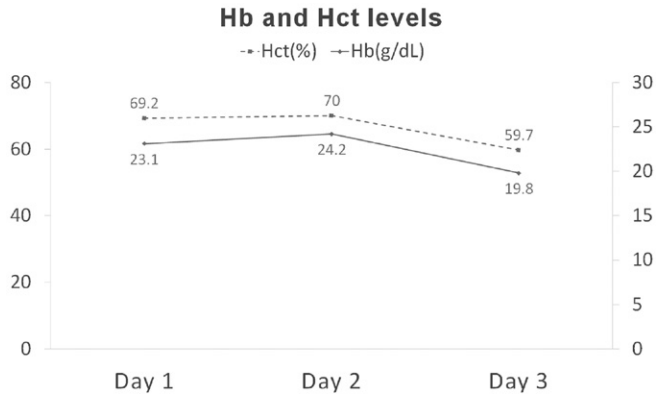

Fig. 2. Hemoglobin (Hb) and hematocrit (Hct) levels were measured at different times both before and following a partial blood exchange.

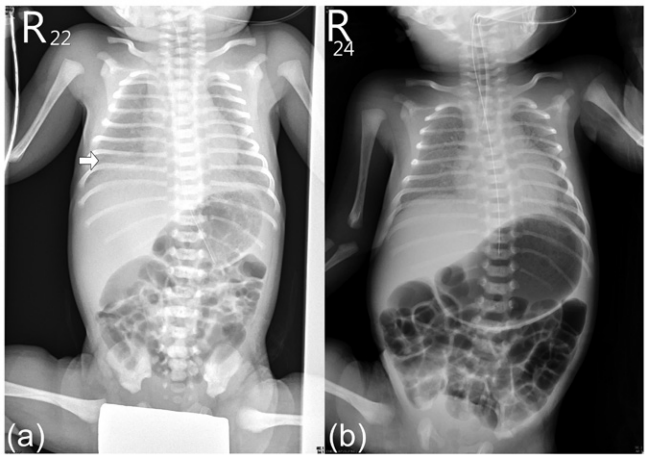

Fig. 1. Chest radiographs: A) shows a reticular granular pattern, grade II–III (arrow); B) taken before air transport.

DISCUSSION

Apart from hypoxia, environmental factors, including noise, vibration, temperature, and reduced humidity, could cause stress to both crewmembers and neonates during air transportation.[3,4,9] Therefore, before air transport, it is crucial to consider all these factors.

As altitude increases and atmospheric pressure decreases (hypobaria), gas volume expands. This can affect air spaces within the human body, including the middle ear, sinuses, gastrointestinal tract and lungs, and the pleural, intracranial, and intraocular spaces.[9] As the gas expands, it can cause significant distress to patients during air transportation. Infants may experience respiratory rates ranging between 40 and 60 breaths/min, whereas older children typically have rates of approximately 20 breaths/min.[11] Additionally, the surface area-to-volume ratio is the highest at birth and decreases as a child grows, making pediatric patients more susceptible to thermal energy loss

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and hypothermia during flight.[11] Therefore, it is important to consider these factors prior to air transportation.

Preterm neonates are at risk of atelectasis due to decreased levels of lung surfactant, resulting in ventilation-perfusion mismatch and hypoxia.[8,11] Aeromedical staff should be aware that in infants the diaphragms are mainly used for respiration because negative intrathoracic pressures are less effective in inspiring air.[8,11] Desaturations were observed in approximately one-third of healthy infants under 6 mo of age during aeromedical transport in a hypobaric hypoxemic condition.[5] Infants tend to become hypoxic due to prematurity or concurrent lung conditions. Moreover, infants easily can experience hypoventilation or apnea when exposed to hypobaric hypoxia during air transport.[8,11] To minimize hypoxia, methods such as oxygen supplementation, maintaining sea-level flight, and reducing disconnection of supplemental oxygen should be employed.[11] Exposure to hypoxic conditions can lead to vasoconstriction of the pulmonary vessels, increasing the risk of right-to-left shunting through a patent foramen ovale and patent ductus arteriosus and nonoxygenated blood returning to the systemic circulation.[11,13] With increasing altitude (hypobaria), expanding intestinal air and pneumothorax are also concerns during flight and mitigating measures such as placing a nasogastric/orogastric tube or chest tube before transport may be necessary. Additional mitigation for hypobaric effects in nonpressurized aircraft includes limiting altitude, as was done in this case. Rapid acceleration and deceleration can lead to a sudden increase in venous cerebral perfusion, which in turn increases the risk of intraventricular bleeding.[1,2,10] Compared with fixed-wing aircraft, typical rotor-wing type cannot provide pressurization, and noise and vibration may be more pronounced.

When planning for neonatal transport, it is important to ensure that essential equipment such as a transport incubator, respiratory support system, T-piece resuscitator, portable oxygen cylinders, vital sign monitors, and syringe pumps are available during transport. However, there may be motion artifacts that would affect the accuracy of the vital sign readings obtained from the monitors during transport. Therefore, it is crucial to prioritize physical assessments rather than solely relying on readings obtained from patient monitors.[4]

The newborn's blood oxygen saturation was unstable during takeoff and landing, which could be attributed to their underlying cardiopulmonary condition. Previous research has indicated that hypoxemia and desaturation are common during air travel in patients with pulmonary hypertension.[10] More than a third of these patients reported symptoms during flights, such as chest pressure/tightness, dizziness, shortness of breath, or palpitations.[7] However, there is limited research on air transportation in neonatal patients, particularly in those with coexisting conditions such as neonatal respiratory distress syndrome or pulmonary hypertension. The hallmarks of clinically significant pulmonary hypertension are hypoxemic right-to-left shunting and cardiac dysfunction, resulting in systemic cyanosis, hypotension, and acidosis.[6] Pulmonary artery pressure increases during simulated air travel in a hypobaric conditions, consistent with previous in-flight observations.[12] Pulmonary hypertension patients face intricate physiological challenges during air transportation due to their compromised cardiopulmonary status. Practitioners should be aware of the potential for exacerbation of right-to-left shunting, alterations in cerebral blood flow, ventilation-perfusion mismatch, hypoxemia, and the risk of cardiac decompensation. The potential impacts on neonates transported by aircraft are illustrated in **Table I**. These conditions can lead to increased stress during flight, particularly during takeoff and landing.

Table I. The Potential Impacts on Neonates Transported by Aircraft.

IMPACT	INFLUENCE
Flight physiology	
Hypobaria	Pressure changes can discomfort neonates and impact their ear and respiratory systems.
Special consideration	
Hypoxia	Reduced blood oxygen saturation
Noise	Short-term exposure to elevated noise levels can lead to fatigue, while long-term exposure to noise can result in hearing loss.
Vibration	Heart rate and respiratory rate are increased, which can contribute to fatigue.
Temperature	Neonates are susceptible to hypothermia in high-altitude environments.
Decreased humidity	Excess fluid loss

This table outlines the key considerations for planning neonatal air transportation.

The success of an air transport mission for a neonate depends not only on factors such as gestational age, bodyweight, or the patient's condition, but also effective collaboration between the hospital staff and aeromedical crew. A well-planned and coordinated approach can minimize the risks and complications that may arise during transport. Beyond the patient's medical condition, environmental factors must also be carefully assessed before planning air transport. Certain cardiopulmonary conditions might affect the transportation process, particularly during takeoff and landing.

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