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STATE OF THE ART

Initial Evaluation and Key Principles of Critically-Ill Pediatric Patient Aerial Transport

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ABSTRACT

Recent advances in more efficient communications, modern telemedicine systems, medical progress, better training of the medical professionals with the possibility of sub-specialisation has led to shorter transfer times in safer conditions of this and overall affording a better chance of survival. High altitude air transport has considerable implications on the respiratory system's efficiency. Caregiver selection is key in avoiding the dangers of debilitating altitude sickness on the medical team. Minimizing physiological or anatomical derangements and minimizing potential complications in the very small critically ill patients while achieving short transfer times are major objectives.

Keywords: Pediatric critical care, air medical transport, evaluation and diagnosis critically ill child, high altitude hypoxemia, aero-medical transport complications

BACKGROUND

Initial evaluation of the critically ill pediatric patient doesn't differ much from that of the critically ill adult. Nevertheless, there are key anatomical and physiological features of the newborn/infant that must be considered during medically-assisted air transport.

Recent advances in more efficient communications, modern telemedicine systems, medical progress, better training of the medical professionals with the possibility of sub-specialisation (in Neonatal Care and Paediatrics) has led to shorter transfer times in safer conditions of this and overall affording a better chance of receiving appropriate and often live-saving treatment to this fragile critically ill pediatric population (Figure 1).

FIGURE 1. Accepting a newborn

High altitude air transport has considerable implications on the respiratory system's efficien-

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cy (reduced air pressure with reduced atmospheric oxygen partial pressure) leading to a compensatory increase in tidal volume and minute ventilation. Owing to this hyperventilatory response the secondary drop in PaCO2 and the consequent respiratory alkalosis produces a left shift in the oxyhemoglobin dissociation curve and a reduced oxygen delivery to the tissues. Hypoxemia then results in a reflex increase in pulmonary arterial pressure through the Von Euler reflex (pulmonary hypoxic vasoconstriction). This becomes critical for the sickest of the patients with reduced cardiac reserve, risking overt decompensation in case of high altitude air transport (Figure 2).

FIGURE 2. SMURD helicopter bringing a child as an emergency to "Marie Curie" Emergency Children's Hospital

When considering the average airplane flight altitude of 11.000 meters the air pressure in the flight cabin drops to approximately 565 mmHg, which is equivalent to that of a helicopter flying at 2.500 meters. If the relative oxygen content stays at 21%, the alveolar partial oxygen pressure drops in relation with the total reduction in atmospheric barometric pressure (21% of 565 mmHg = 119 mmHg which is equal to breathing an 16% oxygen air mixture at sea level). This obviously needs to be compensated by an increase in the FiO_2 for the hypoxic patient.

Another key aspect that should be kept in mind when planning an aerial medical transport is that the small pediatric patients (infants and neonates) (1,2) have a small body mass with less elastic - conjunctive tissue that their larger counterparts which in the case of severe turbulence implies the risk of high severity organ damage and the risk of displacement and/or malfunction of the endotracheal airways and endovascular devices (standard practice dictates that at least one functional iv line should be available). If confronted with the loss of a viable iv line an intraosseous vascular device should be the preferred option for re establishing safe and easy perfusion acces.

To ensure patient safety during the flight all medical equipment should be fastened and the transferred patient should be secured using pneumatic mattresses and security straps2. Also the diagnosis of tracheal tube malposition or pneumothorax by chest auscultation is impossible during the noisy (helicopter / aircraft) cabin in-flight conditions, imposing a heavy reliance on clinical evaluation of thoracic respiratory movements and the appearance of tracheal deviation signs (3).

Radio interference with the aircraft's electrical and communication circuits can disturb normal function of many of the medical devices used during the patient's transfer. To be used safely all electrical medical equipment employed during air transport should be certified by the air transport safety authorities (4).

Considering the long distances sometimes covered by medical air transfer, double the oxygen reserve should be available, especially considering that fluid suctioning equipment uses is oxygen-powered (4).

It should also be kept in mind that at high altitudes gas expands, this implies that tissue air in subcutaneous emphysema patients or pleural air as in traumatic pneumothoraces or pleural drainage patients needs close surveillance as it can expand and potentially cause acute distress3. Also gastric drainage by the means of a gastric tube can evacuate any expanding gastric gas contents, especially considering the frequent nature of critical illness associated ileus.

Body temperature control during the flight is key and needs taking into consideration having backup batteries for the uninterrupted functioning of the incubator. Also, blood sugar management requires frequent sampling during the in-flight period.

Considering the specific challenges and the frequent physiological derangements facing the critically ill neonate/infant, caregiver selection is key in avoiding the dangers of debilitating altitude sickness on the medical team, especially when prophylactic medication fails (5).❑

CLINICAL OR LOGISTICAL CONDITION IMPOSING AERO-MEDICAL TRANSFER

Clinical conditions imposing a very short transfer time or when terrestrial transfer is impractical or impossible due to difficulties reaching the patient by road (6) the utility of such a mode of transportation is obvious.

Does the receiving hospital have a mobile ground unit and a qualified medical team for optimal patient transport?❑

CONCLUSION

Minimizing physiological or anatomical derangements and minimizing potential complications in the very small critically ill patients while achieving short transfer times are major objectives when considering, planning and executing pediatric aerial intensive care transport. Close attention to maintaining a patent airway, while delivering safe and effective mechanical ventilation, to maintaining critical tissue perfusion and hemodynamic stability, to controlling major hemorrhage and to avoiding debilitating complications is of paramount importance. If this pre-requisites are completed and careful consideration is paid to potential physiologic complications while adapting to the demanding conditions of an airplane cabin, in-flight patient care can be safely and effectively delivered.❑

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Table 1. When to consider medicalised air transport (7)
Traumatic score < 12
Unstable vital signs (clinically dangerous hypotension, rapid breathing/tachypneea)
Severe multi-organ pathology
Penetrating thoracic, abdominal, pelvic or head trauma
Fall from considerable height
Neurological considerations
Glasgow Coma Scale < 10
Degrading mental status
Cranial vault fracture
Clinical signs suggesting a possible spinal cord injury
Thoracic considerations
Major thoracic trauma
Pneumothorax/Haemothorax
Abdominal/Pelvic considerations
Severe abdominal traumatic pain
"Seat-belt"sign or other abdominal wall contusion sings
Hypotensive pelvic fractures
Orthopedic considerations
Complete or partial traumatic amputations needing immediate medical evaluation
Vascular lesions/Open fractures/Limb ischemia
Major burns
Burn surface over 20% of the BSA
Smoke inhalation
Chemical or electrical burns
Other considerations
Small gestational age (< 30 weeks), Small birth weight (<2000 grams)
Sepsis
Dependence of mechanical ventilation (controlled or assisted)
Solid organ transplant recipient
Organ donor in brain death for maximizing organ viability/salvage
Adapted from MacDonald M. Guidelines for Air and Ground Transport of Neonatal and Pediatric Patients American Academy of Pediatrics, Elk Grove 1999

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