Original Article

Nasal CPAP on paediatric air transport in the Canadian Arctic: A case series

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Abstract

Aims: Paediatric transport in remote regions of Canada represents a huge challenge given the acuity of the patients, immense distances, weather and lack of road infrastructure. Transport of patients in the Baffin region of Nunavut is completed entirely by air transport. Two very common paediatric transports are in regards to lower respiratory tract infections and premature deliveries in small rural communities north of Iqaluit. Recently, the advent of noninvasive ventilation has been introduced to the region.

Method: We report five cases of long-distance air transport of paediatric patients in respiratory distress using nasal continuous positive airway pressure (nCPAP). Two cases involve lower respiratory tract infections, and three cases involve neonates (two premature infants and one term infant).

Results: Overall, these cases highlight effective and safe use of noninvasive ventilation in air transport of patients in respiratory distress and demonstrate how this modality can improve patient transport in rural and remote regions.

WHAT'S NEW

- Transport in the Arctic regions of Canada represents significant challenges to local health care providers
- nCPAP has been used in several cases reported below to safely transport neonates and paediatric patients in respiratory distress over significant distances by air, avoiding a likely intubation
- nCPAP when used in the appropriate context has significant potential to positively impact paediatric patient outcomes in rural and remote settings

INTRODUCTION

Neonatal and paediatric transport in rural and remote regions of Canada represents a great challenge to clinicians. Transport distances are vast, population density is low, weather is unpredictable, and health facilities have limited resources. The Qikiqtani region in Nunavut is comprised of over 989,879 km² and 18,988 people, the majority of whom are Inuit (1). Nunavut has

a young population, with 40% being under the age of 20. The capital of Nunavut, Iqaluit (population 7,740), is the location of the region's hospital (Qikiqtani General Hospital [QGH]), which has emergency, surgical, and inpatient services provided by a team of local physicians. Iqaluit lies over 2,000 km north of the closest tertiary-level hospital, located in the Canadian capital of Ottawa. The farthest community from Iqaluit (Grise Fiord) lies approximately 1,500 km even further north. All health care in communities within the Qikiqtani Region aside from Iqaluit are provided by health centres staffed by nurses, with periodic supportive visits from physicians. Due to lack of infrastructure for ground transportation between communities, transport is solely by plane. It is not surprising given these challenges that health care expenditures in the region per capita are some of the highest in the world, although health outcomes in the Inuit population lag behind the rest of Canada (2–5).

Two of the most common indications for urgent air medical evacuation of neonatal and paediatric patients in the region are premature birth and respiratory distress secondary to bronchiolitis. Premature infants may require urgent transport to a

tertiary centre following birth, often due to respiratory complications related to prematurity. As for bronchiolitis, rates among the Inuit are well known to be among the highest worldwide, with a hospitalization rate as high as 484 of 1,000 infants in the first 6 months of life, and 12.8% of those admitted requiring intubation and transfer (6–8). Historically, in Nunavut, neonates in significant respiratory distress have required intubation and mechanical ventilation for respiratory support during air transport. The threshold for intubation in remote regions may be lower than in larger centres, due to anticipation of further respiratory decompensation in flight and mitigation of difficulties associated with advanced airway placement in flight.

Until 2016, there were no reliable modalities in the Qikiqtani Region to provide noninvasive ventilation. Advances in noninvasive ventilation (i.e., nasal continuous positive airway pressure) have been thoroughly studied in the hospital setting. It is now well established in the literature that nCPAP decreases chronic lung disease caused by prolonged mechanical ventilation in the newborn period, length of stay in neonatal and paediatric intensive care units (PICU), and overall morbidity and mortality (9–11). Literature suggests that CPAP use during transport of infants with severe bronchiolitis is associated with decreased resource use without a difference in outcome (12). This noninvasive approach has revolutionized neonatal and paediatric care. Since 2016, with acquisition of the *Hamilton-T1 Ventilator*, nCPAP has become an option to manage patients in Nunavut with respiratory distress. To date, there is little in the literature regarding the use of noninvasive ventilation for air transport in Canada. Two large case series published in Australia in 2008 and 2012 highlighted its effectiveness and safety both in bronchiolitis and premature infants for long-distance air transfer (13,14). The following five case reports highlight effective and safe use of nCPAP on air transports for preterm infants and paediatric patients with bronchiolitis in respiratory distress from remote regions in the Qikiqtani region of Canada's Arctic to definitive care in southern Canada.

CASE 1: BRONCHIOLITIS IN A 15-DAY OLD

A 15-day-old ex-36-week infant presented to a remote community health centre with a 1-day history of tactile fever and upper respiratory tract infection symptoms. On arrival, temperature was 38.3°C. A partial septic workup was completed and empiric antibiotics initiated. The infant was transferred to QGH uneventfully (2 hours flight time) with low flow oxygen via nasal prongs. A lumbar puncture was performed on arrival and culture sent. During admission, the patient developed moderate work of breathing and tachypnea (respiratory rate 70 to 80) on 0.75 L/minute of oxygen via nasal prongs. Subsequently, respiratory distress worsened, and capillary blood gas revealed respiratory acidosis with a pH of 7.25, and CO₂ of 62 mmHg. nCPAP was initiated with a pressure of 6 cm H₂O. Blood gas following initiation of nCPAP showed improvements to a pH

of 7.34 and a CO₂ of 39 mmHg. Work of breathing decreased from moderate to mild. The patient was transported to the paediatric tertiary centre in Ottawa (3 hours flight time) on nCPAP with the above settings, and FiO₂ ranging from 29 to 35%. No adverse respiratory events occurred on transport. The patient was admitted on arrival to the PICU on nCPAP of 7 cm H₂O with an FiO₂ between 25 and 30%. Due to worsening respiratory distress, the patient was switched to bilevel positive airway pressure for 4 days, then transitioned back to nCPAP. Two days later, noninvasive ventilation was discontinued and the patient was transferred to a general paediatrics ward.

CASE 2: PNEUMONIA IN A 3-MONTH OLD

A 3-month-old, ex-34-week infant presented to a remote community health centre following a 12-day history of upper respiratory tract infection symptoms. There was initial improvement within the 12 days, but 2 days prior to presentation, worsening respiratory distress occurred with new fevers. The patient presented with a fever of 38.7°C, respiratory rate of 60/minute, heart rate of 194 bpm, and oxygen saturation of 94% on room air. Intravenous (IV) antibiotics and a normal saline bolus were given. Air medical evacuation to QGH was arranged (2 hours flight time). On arrival at QGH in Iqaluit, rectal temperature was 38.0°C, heart rate was 178 bpm, respiratory rate was 54/minute, and oxygen saturation was 97% on 0.25 L of oxygen by nasal prongs. The patient had moderate intercostal indrawing and coarse crackles. A chest x-ray showed a right upper lobe opacification. Antibiotics were continued and the patient was admitted for supportive care and close observation. Over the next 2 days, there was worsening work of breathing with occasional oxygen desaturations. The blood gas showed a respiratory acidosis with a pH of 7.33 and a CO₂ of 52 mmHg. The patient was placed on nCPAP of 7 cm H₂O with an FiO₂ of 24%. Work of breathing improved significantly over the next 1 to 2 hours. Repeat blood gas showed improvement of respiratory acidosis with a pH of 7.40, and CO₂ of 44 mmHg. An air medical team transferred the patient from Iqaluit to Ottawa on nCPAP of 7 cm H₂O, and FiO₂ ranging from 25 to 30%. No adverse respiratory events were reported on transport. The patient was admitted to the PICU in Ottawa on nCPAP of 7 cm H₂O, 25% FiO₂. Respiratory distress worsened while in the PICU and bilevel positive airway pressure was initiated for 3 days before transitioning back to nCPAP. This was later discontinued, and the patient was transferred to the general paediatric ward.

CASE 3: RESPIRATORY DISTRESS SYNDROME IN A 33 + 6-WEEK NEONATE

A 40-year-old G8P6 female presented in labour and had an uneventful spontaneous vaginal delivery at a gestational age of 32 + 6 weeks at QGH. Birth weight was 2,248 g. Minimal

resuscitation was initially required for the infant. APGAR score was 9 at 1 minute of life, and 9 at 5 minutes of life. At 30 minutes of life, the infant began grunting and nCPAP was initiated. Initial pressures were 6 cm H₂O, later increased to 8 cm H₂O due to persistent grunting. Following this increase in pressure, work of breathing and grunting settled. Initial blood gas revealed a pH of 7.24, and CO₂ of 59 mmHg. Two oxygen desaturations into the 70's accompanied with bradycardia occurred, and a dose of IV caffeine was given. No further desaturations or bradycardias were witnessed following this treatment. Blood cultures were drawn and the infant was started on IV antibiotics. The patient was switched onto the transport ventilator with nCPAP of 6 cm H₂O, and transported to Ottawa with no adverse respiratory events. The patient was received in the Ottawa neonatal intensive care unit (NICU), and nCPAP was discontinued after day 2 of life, where the neonate was transitioned to room air.

CASE 4: RESPIRATORY DISTRESS SYNDROME IN A 31 + 2-WEEK NEONATE

A 14-year-old G1P1 female presented in spontaneous labour to a remote community health centre. It was estimated that the gestational age was 31 + 2 weeks. On presentation, the fetal head was crowning. Urgent air medical evacuation was arranged. Membranes ruptured just prior to delivery. No meconium was present at delivery. The community health nurse delivered the baby. The neonate was vigorous following delivery, with APGAR scores of 8 at 1 minute and 9 at 5 minutes of life. Heart rate did not drop below 100 bpm, and spontaneous respiratory effort was always present. At approximately 15 minutes of life, grunting was noted. A self-inflating bag was used to assist with breathing and provide positive end expiratory pressure. At 1.5 hours of life, IV access was established for the administration of fluids and antibiotics. The transport team dispatched from Iqaluit arrived at approximately 3.5 hours of life. On arrival, oxygen saturation was 99% with support from the self-inflating bag on 100% oxygen. Heart rate was greater than 100 bpm, with no described circulation issues. There was mild to moderate work of breathing. The infant was placed on nCPAP of 6 cm H₂O, with 40% oxygen. Oxygen saturations were maintained at 97% following initiation of nCPAP and work of breathing improved over the next 30 minutes. A low-lying umbilical venous line was placed.

The infant was transported to QGH (three hour flight). There were two bradycardic episodes during flight, which were self-resolving with no desaturations or apneas. FiO₂ was weaned to 30% during flight and work of breathing was mild. Due to the stability of the patient, it was collectively decided that the infant would switch planes at the Iqaluit airport and fly directly to definitive care in Ottawa, rather than assessing and stabilizing at QGH. The infant continued to Ottawa. Two further self-resolving bradycardic episodes occurred during flight with no desaturations.

The infant was received in the Ottawa NICU on nCPAP of 6 cm H₂O, FIO₂ of 30%, while maintaining oxygen saturations with mild work of breathing. Capillary blood gas on arrival revealed a pH of 7.26, and CO₂ of 43 mmHg. Two hours after arrival, an x-ray revealed ground glass opacifications, and the infant was electively intubated for surfactant. Extubation occurred within 12 hours and nCPAP was restarted.

CASE 5: TRANSIENT TACHYPNEA IN A TERM NEONATE

A 33-year-old G3P3 had an uneventful scheduled caesarean section at 38 + 4 weeks gestational age. The infant required no resuscitation. APGARs were 9 at 1 minute and 9 at 5 minutes. At 30 minutes of life, the infant was grunting and had increased work of breathing. nCPAP at 6 cm H₂O was started with 35% FiO₂. Work of breathing improved and grunting decreased over the course of the next hour. FiO₂ requirements remained at 30%, and tachypnea persisted. Blood cultures were drawn and IV antibiotics started. Chest x-ray was consistent with transient tachypnea of the newborn. Venous blood gas on nCPAP revealed a pH of 7.24, and CO₂ of 43 mmHg. Transport was arranged to the Ottawa NICU with nCPAP at 6 cm H₂O, 30 to 35% FiO₂ in flight. The 3-hour air transfer was uneventful with no adverse respiratory incidents reported. The patient arrived at the NICU stable on nCPAP with cunahged settings. nCPAP was continued for three days and gradually weaned. The patient was discharged from hospital at day of life 7 and returned home.

DISCUSSION

The above five cases highlight challenges relating to medical transport across the vast distances in rural and remote Canada. The advantages of noninvasive modalities such as nCPAP are explored, which have only recently become available to transportation teams in the Qikiqtani region. Without the use of nCPAP, it is likely that each of the above cases would have required intubation prior to air transport. This is known to increase length of stay in intensive care settings (13). In addition to decreasing length of stay, many other undesired side effects of intubation and invasive ventilation are avoided with noninvasive ventilation. These include risks of failed intubation in rural and remote settings with minimal back up and limited equipment, upper airway trauma, barotrauma and volutrauma on the lungs, exposure to sedative medications and paralytics, increased risk of ventilator-associated pneumonias, and increased long-term rates of poor compliance and chronic lung disease.

There is a paucity of literature on the use of nCPAP in medical air transport in Canada. Two case series published in Australia have shown overall safety and efficacy in avoiding intubation (13,14). The above five cases are the first to be reported in the

literature of successful paediatric air transport utilizing nCPAP in North America. Although this study has the limitation of being a retrospective case series as opposed to a prospective trial, the cases do suggest nCPAP can be used safely and successfully for long-distance air transport in the neonatal and paediatric population. No adverse events were recorded and all patients arrived for definitive care in a stable condition. The fourth case involved a total flight time of over 6 hours while utilizing nCPAP. This was broken into two flights, as an airplane change was required at the Iqaluit airport, without the patient being transferred to the hospital there. This represents a significant flying time, and is longer than any record of a paediatric patient on nCPAP in flight reported in the literature.

It is critical to outline that nCPAP on medical air transport should only be pursued in carefully selected situations in which the patient has shown clinical improvement following its initiation and prior to flight, and the medical team understands how to assess if a patient is responding well to the nCPAP, as well as the contraindications and potential complications that might occur during flight. Potential risks that are unique to nCPAP during air transport include but are not limited to lack of a protected airway, inability to tend to pulmonary toilet, air leak and mask fit issues and delay in surfactant administration.

As we tackle issues of distance and remoteness in the Canadian north while always striving to provide the best possible health care, noninvasive ventilation represents an exciting opportunity to decrease morbidity in neonates and paediatric patients in respiratory distress. Each case must be carefully selected for this modality, and improvement and stability on nCPAP must be achieved prior to flight. nCPAP is a viable option for the transport of paediatric patients in respiratory distress in rural and remote settings in the Canadian Arctic, and air transport providers should consider including this modality in their armamentarium of essential medical equipment used in flight. For the Qikiqtani region, this has already represented a significant improvement in overall care and positive outcomes. In the future, with increased cases of nCPAP on air transport in the Qikiqtani region, examination of a retrospective case series would be critical to continue to monitor efficacy as well as any adverse events and the frequency at which they occur.

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Conflict of Interest

The authors have no known conflicts of interest and no financial disclosure.

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