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Non-invasive ventilation during interfacility air and ground medical transports

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INTRODUCTION

Critically ill patients transferred to a healthcare facility often require mechanical ventilatory support due to respiratory distress, which can be managed using non-invasive ventilation (NIV) or invasive ventilation. The main NIV modalities are continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), and high-flow nasal cannula (HFNC). The choice of ventilatory modality and the need to humidify the airways to compensate for the cooling and drying effects of ventilation gases during interfacility transfers depend primarily on the patient's clinical condition and the anticipated risk of deterioration, as well as other factors such as duration and and type of the medical transportation (air or ground). Invasive ventilation also requires advanced expertise and is associated with a higher risk of barotrauma, laryngotracheal stenosis, ventilator-induced lung injury, and weaning failure than NIV. The Health Technology Assessment Unit (UETMIS) of the CHU de Québec – Université Laval (hereinafter referred to as CHU de Québec) was mandated to evaluate practice's effectiveness and safety related to NIV during air and ground transports of children and adult requiring respiratory support.

DECISION-MAKING QUESTION

Should practices related to non-invasive ventilation during ground medical transports at CHU de Québec and air transports under the Évacuations aéromédicales du Québec (EVAQ) program be modified?

METHODOLOGY

A literature review was conducted across multiple bibliographic databases and other sources to identify applicable standards and regulations for medical devices used in transports, clinical practice guidelines, systematic reviews, and original studies on NIV during interfacility transfers published in French or English between January 1st, 2010, and August 15th, 2025. Main outcomes included respiratory escalation (including intubations) and mortality during transports, and up to 24 hours after intensive care unit (ICU) admission, respiratory complications during transports, and variations in physiological respiratory parameters. Incident reports related to the use of transport ventilators during interfacility transfers were retrieved from government adverse event databases (American Food and Drug Administration, Health Canada) and CHU de Québec's information system on the safety of care and services. Semi-structured interviews were conducted with staff from EVAQ program and those involved in ground medical transports at the CHU de Québec and other University hospitals in Québec (CHU Ste-Justine, Hôpital de Montréal pour enfants, Centre intégré universitaire de santé et de services sociaux de l'Estrie - Centre hospitalier universitaire de Sherbrooke, Institut universitaire de cardiologie et de pneumologie de Québec). A survey on mechanical ventilation practices in various air transport programs in Canada and abroad was also carried out. Administrative data from a national [1] and a local hospitalisation databases databases were analyzed to identify intubations performed in CHU de Québec emergency departments and within 24 hours of hospitalization following ground or air

[1] Med-Echo : Maintenance et exploitation des données pour l'étude de la clientèle hospitalière

transports during fiscal year 2023–2024. Data on air transports between 2021 and 2024 were extracted from the EVAQ program's latest activity report.

RESULTS

What are the best practice recommendations and safety standards for NIV during air and ground medical transports?

Three expert groups have provided recommendations on interfacility transports and mechanical ventilation. These documents include general guidelines on transfer decisions and planning, team competency requirements, and medical equipment selection. For mechanical ventilation, endotracheal intubation is recommended for adult patients being transferred due to cardiac arrest or brain injury with a Glasgow scale score equal or lower than 8 or significant deterioration in consciousness. Gases administered to patients under invasive or non-invasive ventilation should be humidified using a heat and moisture exchanger (HME) according to one organization. An expert consulted indicated that airway humidification is likely unnecessary when using a turbine ventilator (no external compressed gas source) for short periods if the fraction of inspired oxygen (FiO_2) is below 50 %.

Canadian Medical Devices Regulations (SOR/98-282) require Health Canada approval for Class II, III, and IV medical devices, certifying safety and effectiveness. Transport ventilators (Class III) and heated humidification circuits (Class II) must be approved, but not HMEs (Class I). The Canadian standards on medical electrical equipment (CSA 60601-1-12), which is not mandatory, sets general safety and performance requirements for devices used in emergency medical environments, including interfacility transports. For air transports, certified restraint devices are required under Canadian Aviation Regulations (SOR/96-433); for ground transports, SAE J3043 and BNQ 1013-110 standards apply.

What is the effectiveness of NIV during air and ground medical transports?

Studies on CPAP, BiPAP, or HFNC in neonatology (n = 8) and pediatrics (n = 10) mainly involved ground transfers (81 % (989 / 1183) and 78 % (1148 / 1467) and 78 %, respectively). According to data from observational studies, NIV during interfacility transports of neonates or young children is used for stable, well-selected patients transferred by qualified teams. Intubation during medical air and ground transports under NIV is a rare adverse event. No intubations were reported in five CPAP studies, whereas five cases (2.6 %) occurred in one HFNC study. In pediatrics, one (0.9 %) intubation under CPAP occurred during air transports. Few changes in blood gas indicators were observed. Intubations within 24 hours post-interfacility transfers could reach 18 % in neonatal and pediatric patients, but causality with medical transport or natural progression of the disease is unclear.

The evaluation of the effectiveness of NIV during interfacility transports in adults is based on a smaller number of studies conducted on the use of CPAP or BiPAP (n = 4) or HFNC (n = 1). These studies have mostly focused on air transports (69 %). Data suggest that the use of intubation during transports under NIV is a rare adverse event. No cases of intubation during air transport of adults on CPAP or BiPAP were observed in studies that included 20 to 50% of patients transferred due to a COPD exacerbation or cardiogenic pulmonary edema. Two (4.9 %) intubations were reported among 41 ground transfers of COVID-19 patients under HFNC. Intubations within 24 hours after interfacility transfers were reported for 12 (20.7 %) patients in one study, but a causal link with the use of NIV cannot be established. Data on indicators of physiological changes in respiratory function during transport or respiratory escalation after admission to ICU are insufficient to make a judgment on the administration of NIV during medical transport.

What is the safety of NIV during air and ground medical transports?

No deaths occurred during transports in four neonatal or pediatric studies reporting this indicator. The data do not suggest a link between NIV administered during interfacility transfer and death observed during intensive care hospitalization in one study. Respiratory complications (bradycardia, desaturation, apnea, pneumothorax) have been observed during some interfacility transports but remain infrequent adverse events. Interventions were sometimes required following these complications, but without any other consequence than repositioning the mask or ventilation cannula or administering sedation.

No deaths have been reported during ground or air transports of adult patients on NIV in the two studies that examined this indicator. Furthermore, few cases of complications (mask intolerance, fatigue, hypotension, cardiorespiratory arrest) during air transports were observed in two studies, and a link with the ventilation modality cannot generally be established.

What are the practices related to NIV during ground medical transports to university health centers in Québec and air transports under the EVAQ program and other Canadian or international programs?

According to data from the survey conducted in University hospital centres in Québec, the ventilation method chosen for the management of respiratory distress during interfacility ground transports, in neonatology and pediatrics, is determined by the physician of the receiving center in collaboration with the one of the referring center. NIV is preferred due to the risks associated with endotracheal intubation for newborns and young children. This decision is not based on standardized protocols or guidelines but on clinical judgment. In neonatology, transports are carried out by a specialized team made up of a neonatal nurse and a respiratory therapist; a physician is rarely present. For pediatric transports, a physician is generally present, as specialized teams have been deployed recently in Québec University hospital. Except for one center, ground transports for adults are not carried out by specialized teams dedicated to this purpose. NIV is rarely used for these patients and is reserved for short ground transports.

Data were obtained from the EVAQ program and six air transport programs in Canada (n = 2), Australia (n = 2), the United Kingdom (n = 1), and Ireland (n = 1). NIV practices in these programs are heterogeneous. In neonatology and pediatrics, NIV is sometimes used (EVAQ) or in proportions ranging from 14 to 59 % in other programs. Preferred ventilation modes differ, with some using HFNC while others prefer CPAP. Data on the type of ventilation during interfacility transports of adults are available for two programs. Invasive ventilation is the preferred ventilation mode for approximately half of the transports in one program in Australia and for the majority of those performed by EVAQ services. Some programs have policies or guidelines to inform the choice of ventilatory support during interfacility transports.

Practices related to airway humidification also vary. For ambulance transfers, humidification is considered either essential or dispensable. Reasons given for not humidifying the airways are the sufficient relative humidity provided by the ambient air produced by the turbine, the performance of the ventilator used, or the short distance traveled. For air transports, humidification is used with NIV in most of the surveyed transport programs.

What would be the organizational impacts of a change in practices relating to the use of NIV during air and ground medical transports?

It was not possible within the scope of this report to assess the impacts of a change in practices related to the use of NIV during medical transports. The various ventilation modalities used during interfacility ground transports are poorly documented in the clinical and administrative databases of the CHU de Québec. The same is true for air transports carried out within the EVAQ program. The implementation of tools is desirable in this context to potentially collect data on the characteristics of transferred patients, ventilation modalities, physiological parameters of respiration, observed complications, and the use of humidification. Regarding organizational impacts for the CHU de Québec related to requirements of specialized resources for the use of NIV, effects appear limited considering the existence of a specialized neonatology transport team and the ongoing implementation of a specialized pediatric transport team.

DISCUSSION

- NIV during neonatal and pediatric interfacility transports is a viable option for safe and effective respiratory distress management under certain conditions.
- NIV during interfacility transports in neonatology and pediatrics is a growing practice, but application modalities vary.
- NIV during adult interfacility transports is rare, with limited evidence on effectiveness and safety.

RECOMMENDATIONS

- Direction mère-enfant Soleil and Direction des soins critiques of CHU de Québec, and Direction du consortium provincial interétablissements EVAQ should consider NIV as an option for managing respiratory distress in neonates and young children during ground and air transports by specialized teams.
- For adults, NIV should be reserved for patients requiring ventilatory support during ground or air transports, accompanied by a physician skilled in intubation and following risk assessment.

CONCLUSION

The data collected in this evaluation suggest that NIV for interfacility transports of selected patients transferred by qualified and experienced staff is a safe practice. Implementing recommendations requires stakeholder collaboration to develop protocols or guidelines ensuring continuity of safe and high-quality care for neonatal, pediatric, and adult populations.

Full report (in French): Évaluation de la ventilation non invasive durant les transports médicaux interétablissements