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High-flow nasal cannula implementation has not reduced intubation rates for bronchiolitis in Canada

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Abstract

Background and Objective: Bronchiolitis is the most common reason for admission to hospital in the first year of life, with increasing hospitalization rates in Canada. Respiratory support with high-flow nasal cannula (HFNC) is being routinely used in paediatric centres, though the evidence of efficacy is continuing to be evaluated. We examined the impact of HFNC on intubation rates, hospital and paediatric critical care unit (PCCU) length of stay (LOS), and PCCU admission rates in paediatric tertiary centres in Canada.

Methods: We conducted a multicentre, interrupted time series analysis to examine intubation rates pre- to postimplementation of HFNC for bronchiolitis. Data were obtained from the Canadian Institute for Health Information database. Paediatric tertiary centres that introduced HFNC between 2009 and 2014 were included, and data were collected from April 2005 to March 2017.

Results: A total of 17,643 patients met inclusion criteria. There was no significant change in intubation rates after the introduction of HFNC. There was a significant increase in PCCU admission, with a decrease in the PCCU LOS following the introduction of HFNC. There was no significant change in average hospital LOS after HFNC was introduced.

Conclusions: This study adds to the evolving evidence showing that overall disease course is not modified by the use of HFNC. The initiation of HFNC in Canadian paediatric centres resulted in no significant change in intubation rates or average LOS in hospital, but had an increase in PCCU admissions. Careful monitoring of new technologies on their clinical impact as well as health care resource utilization is warranted.

Keywords: *Bronchiolitis; High-flow nasal cannula; Intensive care units; Intubation; Paediatric.*

Bronchiolitis is an extremely common viral lower respiratory tract infection affecting more than one-third of children less than 2 years of age and is the most common reason for hospital admission in the first year of life (1). Hospitalization rates for bronchiolitis have been on the rise in Canada, leading to increases in health care expense, morbidity, impact on families, and critical care resources (1). Clinical practice guidelines for infants with bronchiolitis from Canada and the United States advocate for the use of supportive care, including supplemental oxygen, as the evidence for the majority of interventions currently used is equivocal (1).

Children with more severe bronchiolitis have poor pulmonary compliance and high pulmonary resistance, which lead to increased respiratory effort and potential respiratory failure.

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Noninvasive ventilation (NIV) support (i.e., CPAP/BiPAP) can be used to support respiratory function in bronchiolitis to improve ventilation and oxygenation without the use of an endotracheal tube, with its associated adverse events (2). However, NIV support can be challenging to deliver due to patient agitation, frequent air leaks, and pressure sores from the mask interface (3).

High-flow nasal cannula (HFNC) is an alternative to NIV that can be applied to provide respiratory support to patients with bronchiolitis through high flows of heated, humidified oxygen. It does not create a seal at the patient interface, and therefore, pressures delivered cannot be measured and the significance of the pressure provided has not yet been determined (4). However, the HFNC interface is easier to configure than NIV masks and is also generally considered more comfortable and better tolerated by patients (4). The rapid adoption of HFNC in bronchiolitis has outpaced the evidence, with recent acceleration in investigation as to its efficacy. Physiologic studies have shown HFNC is associated with decreased work of breathing and respiratory rate (5). However, it remains unclear if HFNC has a clinical impact on disease course or severity, as current studies have shown differing outcomes (6–11).

Intubation is an objective clinical outcome that represents a severe disease course. The ability to prevent this outcome would have a significant clinical impact for the patient in reduced invasiveness and iatrogenic complications, as well as resource and financial savings to the health care system. Our primary objective was to examine the effect of the introduction of HFNC in Canada on intubation rates for paediatric patients with bronchiolitis. We hypothesized that the introduction of HFNC has resulted in decreased intubation rates. Our secondary objectives were to determine the impact of HFNC on paediatric critical care unit (PCCU) admission rate, PCCU length of stay (LOS), and total hospital LOS.

METHODS

Study design

We conducted a multicentre, interrupted time series analysis for children <2 years old with bronchiolitis. Time series analysis is a method of disease incidence prediction using past values to detect and forecast trends, while controlling for variability in the data. Paediatric tertiary care centres in Canada that introduced HFNC between 2009 and 2014 were included, and data were collected from April 2005 to March 2017. The centres included range in size and catchment area, and all centres are regional paediatric trauma centres and have PCCU beds. The smallest centre is the only tertiary care centre in the province, with 45 inpatient paediatric beds, 8 PCCU beds, and a catchment area of 1.1 million. The largest centre is one of 4 paediatric centres in the province with 300 inpatient paediatric beds, 41 PCCU beds, and a catchment area population of 5 million. This study was approved by Western University's Health Science Research Ethics Board.

Data collection

Data were obtained from the Canadian Institute for Health Information (CIHI) database. CIHI is a nationwide independent and not-for-profit organization that collects data from various databases and provides de-identified data requested (12). Data collected from centres in the Province of Quebec were excluded, as they were not available through CIHI. Of the remaining 10 Canadian paediatric centres, 9 had implemented HFNC during our study period. Study participants were identified using the Canadian Coding Standards, specifically ICD-10-CA codes for diagnosis data. Outcomes were measured using Canadian Classification of Health Interventions (CCI) codes for intervention data to capture intubation. LOS data (in days) and level of care (ward versus PCCU) were also collected. Health administrative data from CIHI has been validated for RSV-related disease, the most common cause of bronchiolitis, in capturing LOS, PCCU admission, and intubation (13). Data to identify NIV use was not shown to be sensitive and was therefore not captured in our study.

Inclusion/exclusion criteria

All patients with any discharge diagnosis of bronchiolitis identified by ICD10 class J21 with age <2 years old at admission were included. We excluded infants who were <37 weeks gestation, or had chronic lung diseases, trisomy 21, congenital heart disease, or immunodeficiency.

Outcome measures

The primary outcome was the intubation rate before and after the first paediatric centre introduced HFNC in June 2009. Secondary outcomes included rate of PCCU admission, hospital LOS and PCCU LOS. Additional demographic data obtained included age, gender, and Respiratory Syncytial Virus status.

Statistical analysis

SPSS v.24 (14) was used for all analyses, using ARIMA (auto-regressive, integrated, moving average) modeling on quarterly data over the study period to account for variability and seasonal effects in the outcomes. All models were adjusted as ARIMA (0,0,4), which accounted for best model fit. HFNC was first introduced in June 2009; therefore, the start of the intervention period was classified at the next available quarter (September 2009).

RESULTS

There were 19,813 admissions for bronchiolitis over the study period (April 2005 to March 2017). There were 2,216 patients

excluded because of comorbidities, leaving 17,643 patients in our analysis (Figure 1).

There was no change in intubation rates before and after the introduction of HFNC in Canada (Figure 2a). However, the PCCU admission rate increased relative to the trend prior to HFNC introduction (Figure 2b). In particular, after the introduction of HFNC, there was an average increase in the PCCU admission rate of 0.38% (SE=0.07%) with each additional quarter.

Despite the increase in PCCU admission rate, there was a decrease in average PCCU LOS. The PCCU LOS had an increasing trend prior to HFNC introduction (M per quarter=0.29%, SE=0.09%, P=0.002) with a drop at the time of HFNC introduction (M=−3.29%, SE=0.96%, P=0.001), followed by a significant decrease (M per quarter=−0.29%, SE=0.10, P=0.007) in the PCCU average LOS trend relative to the trend prior to introduction of HFNC (Figure 2c). HFNC introduction was not associated with a change in the overall average hospital LOS trend relative to the trend prior to HFNC (Figure 2d).

DISCUSSION

This is the first study in Canada to examine HFNC impact on intubation rate, as well as the study with the largest paediatric HFNC cohort reported in the literature to date (N=17,643). Despite the lack of rigorous scientific evidence, uptake of HFNC has been rapid. Previous studies have shown that HFNC is associated with a physiologic response leading to a reduced respiratory rate and work of breathing (5,15). However, when looking at disease course as represented by intubation, PCCU admission or hospital LOS, findings have been conflicting (6–9). Preliminary single-centre retrospective studies have not shown consistent outcomes on intubation rates following implementation of HFNC, with two centres showing decreased intubation rates (6,7) and one showing no effect (10). A recent multicentre randomized control trial in bronchiolitis managed outside of the PCCU, though not powered to look at intubation, showed that those who received HFNC had lower rates of escalation of care than those treated with standard oxygen therapy (8). Overall, we found that intubation rate did not change after HFNC was introduced across the country. Our study adds to the body of evidence suggesting that HFNC does not impact bronchiolitis disease course, as captured by these outcome measures.

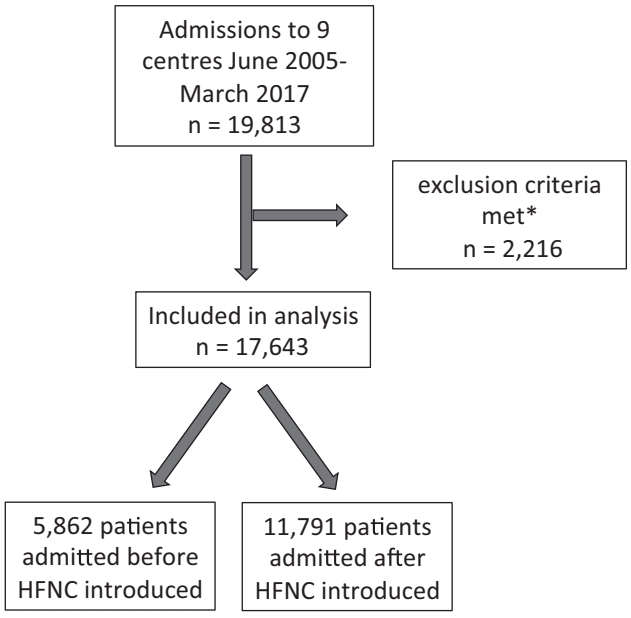

Figure 1. Patient flow diagram. *Excluded if prematurity, chronic lung disease, congenital heart disease, Trisomy 21, or immunodeficiency present.

It is important to continually evaluate the effect of new treatment modalities on hospital resource utilization and clinical outcomes, because if not measured, many unintended consequences can develop. Implementation of new technology can have secondary resource allocation consequences that were not initially predicted. As mentioned, HFNC introduction did coincide with increasing PCCU admission rates and a decrease in average LOS in the PCCU. In Canada, HFNC use for bronchiolitis has had significant uptake over the past decade, with seven of the nine centres studied using it exclusively in the PCCU during our study period; this may have contributed to the increase in PCCU admissions. PCCU admission and LOS outcomes have a significant impact on patient morbidity and mortality, patient and family experience, as well as health care resource allocation and expenditure. Recent literature suggests HFNC may not be the optimal form of NIV for patients with severe bronchiolitis in the PCCU setting (11). Rather, HFNC may be best utilized to prevent those with moderate bronchiolitis from progressing to the point of requiring higher levels of critical care monitoring (8,9).

It is unknown if there are factors that might affect admission rates to PCCU in Canada that were not measured in our study, such as trends in annual virus severity or quality improvement initiatives that looked at optimizing patient hospital flow. It will be beneficial to look at the impact that HFNC implementation on general paediatric wards has on PCCU admission rates and resource utilization in Canada. Although we would hypothesize that the implementation of a HFNC ward policy would help decrease PCCU utilization, it has been suggested that implementing a HFNC ward policy does in fact not impact PCCU resource utilization (10). Future randomized studies are required to better delineate these clinical and economic outcomes, especially since this study adds to the evolving evidence showing that overall disease course is not modified by the use of HFNC.

The current body of evidence may lead us to consider that the role of HFNC in a tertiary care centre is to prevent and rescue some of these patients with moderate bronchiolitis from

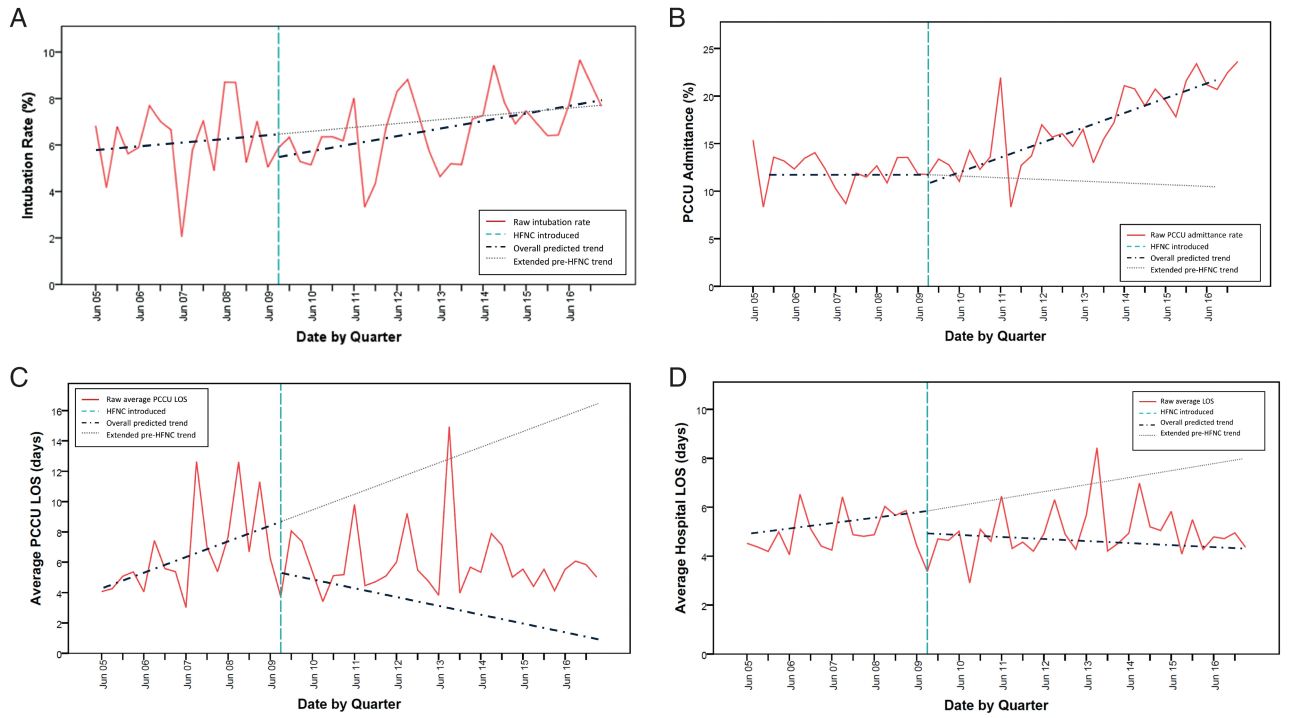

Figure 2. (a) Intubation rate with overall predicted trend pre- and post-high-flow nasal cannula (HFNC) introduction (P=0.39). P-value represents the difference in pre- and postimplementation slope. (b) Paediatric critical care unit (PCCU) admission rate with overall predicted trend pre- and post-HFNC introduction (P<0.001). P-value represents the difference in pre- and postimplementation slope. (c) Average PCCU length of stay (LOS) in days with overall predicted trend pre- and post-HFNC introduction (P=0.01). P-value represents the difference in pre- and postimplementation slope. (d) Average hospital LOS in days with overall predicted trend pre- and post-HFNC introduction (P=0.27). P-value represents the difference in pre- and postimplementation slope.

needing to be transferred to the PCCU. Consequently, many centres are adapting policies in order to increase the use of HFNC on the medical wards. Our study reinforces that disease severity is unchanged (as witnessed by unchanged intubation and hospital LOS); judicious continued monitoring should be advocated for in patients placed on HFNC in order to detect changes in patient state. Use of HFNC should not cloud clinical judgment, and criteria for referral to the PCCU should be upheld. Patients on HFNC who remain in respiratory distress should be as vigilantly monitored with timely referral to critical care services as those without HFNC.

Our study was limited by the nature of its design being retrospective. There was no control population or adjustment for disease severity, though we accounted for this in our study design by using a time series analysis. Implementation of HFNC was not simultaneous across centres, and therefore, an implementation time of June 2009 was chosen, as this was when the first centre introduced HFNC. This was chosen to be inclusive of all centres that introduced HFNC. This study only included previously well infants. Because we used a database to collect our data, we were unable to gather clinical measures such as respiratory rate or heart rate that could help to better capture clinical response to HFNC. We were also unable to gather time data for duration of intubation. This study only included tertiary care centres where PCCUs were located in the same institution and, therefore, cannot be applied to the community hospital setting.

CONCLUSION

Using an interrupted time series analysis, we found that initiating HFNC in Canadian paediatric centres resulted in no significant change in intubation rates or average LOS in hospital from April 2005 to March 2017, but was associated with an increase in PCCU admissions and a decrease in PCCU average LOS. These findings suggest that HFNC does not prevent intubation in patients with bronchiolitis, as has been previously suggested (6,7). Safety studies and judicious clinical criteria for use of HFNC on the ward in the tertiary care setting may address rising PCCU admission rates. Careful monitoring of new technologies is warranted in terms of their clinical impact as well as health care resource utilization.

Contributors Statement: HG and RKL conceptualized and designed the study, developed the detailed database data requisition, drafted the initial manuscript, and reviewed and revised the manuscript. ACG gathered current HFNC practices in Canada, helped draft the initial manuscript, and reviewed and revised the manuscript. MRM developed the detailed database data requisition, carried out the initial analysis, and reviewed and revised the manuscript.

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Ethics Approval: Western University's Health Sciences Research Ethics Board.

References

1. Friedman JN, Rieder MJ, Walton JM; Canadian Paediatric Society, Acute Care Committee, Drug Therapy and Hazardous Substances Committee. Bronchiolitis: Recommendations for diagnosis, monitoring and management of children one to 24 months of age. Paediatr Child Health 2014;19(9):485–98.
2. Pedersen MB, Vahlkvist S. Comparison of CPAP and HFNC in management of bronchiolitis in infants and young children. Children (Basel) 2017;4(4):E28.
3. Sinha IP, McBride AKS, Smith R, Fernandes RM. CPAP and high-flow nasal cannula oxygen in bronchiolitis. Chest 2015;148(3):810–23.
4. Haq I, Gopalakaje S, Fenton AC, McKean MC, J O'Brien C, Brodlie M. The evidence for high flow nasal cannula devices in infants. Paediatr Respir Rev 2014;15(2):124–34.
5. Pham TM, O'Malley L, Mayfield S, Martin S, Schibler A. The effect of high flow nasal cannula therapy on the work of breathing in infants with bronchiolitis. Pediatr Pulmonol 2015;50(7):713–20.
6. McKiernan C, Chua LC, Visintainer PF, Allen H. High flow nasal cannulae therapy in infants with bronchiolitis. J Pediatr 2010;156(4):634–8.
7. Schibler A, Pham TM, Dunster KR, et al. Reduced intubation rates for infants after introduction of high-flow nasal prong oxygen delivery. Intensive Care Med 2011;37(5):847–52.
8. Franklin D, Babl FE, Schlapbach LJ, et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. N Engl J Med 2018;378(12):1121–31.
9. Kepreotes E, Whitehead B, Attia J, et al. High-flow warm humidified oxygen versus standard low-flow nasal cannula oxygen for moderate bronchiolitis (HFWHO RCT): An open, phase 4, randomised controlled trial. Lancet 2017;389(10072):930–9.
10. Riese J, Porter T, Fierce J, Riese A, Richardson T, Alverson BK. Clinical outcomes of bronchiolitis after implementation of a general ward high flow nasal cannula guideline. Hosp Pediatr 2017;7(4):197–203.
11. Milési C, Essouri S, Pouyau R, et al.; Groupe Francophone de Réanimation et d'Urgences Pédiatriques (GFRUP). High flow nasal cannula (HFNC) versus nasal continuous positive airway pressure (nCPAP) for the initial respiratory management of acute viral bronchiolitis in young infants: A multicenter randomized controlled trial (TRAMONTANE study). Intensive Care Med 2017;43(2):209–16.
12. CIHI. Canadian Institute for Health Information. https://www.cihi.ca/en/about-cihi. Published 2018. (Accessed November 2, 2018).
13. Pisesky A, Benchimol EI, Wong CA, et al. Incidence of hospitalization for respiratory syncytial virus infection amongst children in Ontario, Canada: A population-based study using validated health administrative data. PLoS One 2016;11(3):e0150416.
14. IBM SPSS Statistics for Windows [computer program]. Version Version 24.0. Armonk, NY: IBM Corp., 2016.
15. Milési C, Baleine J, Matecki S, et al. Is treatment with a high flow nasal cannula effective in acute viral bronchiolitis? A physiologic study. Intensive Care Med 2013;39(6):1088–94.