



Use of high-flow nasal cannula in infants with viral bronchiolitis outside pediatric intensive care units

Mélanie Panciatici¹ · Candice Fabre¹ · Sophie Tardieu² · Emilie Sauvaget³ · Marion Dequin¹ · Nathalie Stremmer-Le Bel¹ · Emmanuelle Bosdure¹ · Jean-Christophe Dubus^{1,4}

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Abstract

High-flow nasal cannula (HFNC) is frequently used in infants with acute viral bronchiolitis outside pediatric intensive care units (PICU). A structured questionnaire was sent out to pediatricians of all public French hospitals with pediatric emergency and/or general pediatric departments on their use of HFNC outside PICU (department using HFNC, number of available devices, monitoring, criteria for initiating or stopping HFNC, and personal comments on HFNC). Of the 166 eligible hospitals, 135 answered (96 general and 39 university hospitals; 81.3%), for a total of 217 answering pediatricians. Seventy-two hospitals (53.3%) used HFNC in acute bronchiolitis outside PICU, particularly, general hospitals (59.4% vs 38.5%), and mostly in pediatric general departments (75%). Continuous patient monitoring with a cardiorespiratory monitor was usual ($n = 58$, 80%). Nursing staff was responsible for 2.7 children on HFNC and checked vital signs 8.6 times per day. Criteria for HFNC initiation and withdrawal were not standardized. Pediatricians had a positive opinion of HFNC and were willing to extend its use to other diseases.

Conclusion: Use of HFNC outside PICU in infants with acute bronchiolitis is now usual, but urgently requires guidelines.

What is Known:

- Acute viral bronchiolitis treatment is only supportive
- High-flow nasal cannula (HFNC) is a respiratory support accumulating convincing clinical evidence in bronchiolitis
- This latter treatment is usually proposed in pediatric intensive care unit (PICU)

What is New:

- HFNC are increasingly used outside PICU in bronchiolitis, particularly, in general hospitals and in pediatric general departments
- Pediatricians are enthusiastic about this device, but validated criteria for initiation and withdrawal are lacking
- Guidelines for the use of HFNC outside PICU are urgently required

Keywords Bronchiolitis · High-flow nasal cannula · Infant · Intensive care

Mélanie Panciatici and Candice Fabre are declared as co-first authors

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✉ Mélanie Panciatici
melanie.panciatici@ap-hm.fr

Candice Fabre
candice.fabre@ap-hm.fr

Sophie Tardieu
sophie.tardieu@ap-hm.fr

Emilie Sauvaget
esauvaget@hopital-saint-joseph.fr

Marion Dequin
marion.dequin@ap-hm.fr

Nathalie Stremmer-Le Bel
nathalie.stremmer@ap-hm.fr

Emmanuelle Bosdure
emmanuelle.bosdure@ap-hm.fr

Jean-Christophe Dubus
jean-christophe.dubus@ap-hm.fr

- ¹ Service de Médecine Infantile et Pneumologie pédiatrique, CHU Timone-Enfants, 264 rue Saint-Pierre, 13385 Marseille Cedex 5, France
- ² Service d’Evaluation médicale, Pôle de Santé publique, Hôpital de la Conception, Marseille, France
- ³ Service de pédiatrie, Hôpital Saint-Joseph, Marseille, France
- ⁴ IRD, AP-HM, MEPHI, IHU-Méditerranée Infection, Aix Marseille Université, Marseille, France

Abbreviations

GHC	General hospital center
UHC	University hospital center
HFNC	High-flow nasal cannula
PED	Pediatric emergency department
PGD	Pediatric general department
PICU	Pediatric intensive care unit

Introduction

Bronchiolitis is an acute viral affection of the lower airways. It is mostly caused by the respiratory syncytial virus [11] and is the main cause of infant hospitalization in France [2]. Awaiting available antiviral treatments, bronchiolitis treatment is currently only supportive and consists in the medical care of respiratory failure and associated complications, especially hypoxemia and feeding difficulties [6, 22, 28].

High-flow nasal cannula (HFNC) is a noninvasive respiratory support providing the patient a blending of conditioned gas (heated and moistened) through a nasal cannula interface [23]. Possible HFNC beneficial effects in bronchiolitis rely on multiple mechanisms: reduction of inspiratory resistance, wash-out of the nasopharyngeal anatomic dead space, reduction of metabolic work due to gas conditioning, improvement of airways conduction and of mucociliary clearance via the inhalation of heated and moistened gas, and eventually, the creation of a low level of positive pressure inside the airways [4, 20]. This respiratory support, which was until now the prerogative of pediatric intensive care units (PICU), seems to be increasingly used in pediatric emergency departments (PEDs) and pediatric general departments (PGDs). The aims of our study are to describe the use of HFNC in bronchiolitis care inside these two medical wards and to investigate the criteria applied by French pediatricians for the initiation, monitoring, and discontinuation of HFNC in such a situation.

Material and methods

Study type

This is an observational study carried out during the 2017–2018 epidemic period inside PEDs and PGDs on the national territory (France).

Selection criteria

Names and e-mail addresses of pediatricians working in public hospitals with an identified pediatric activity were collected from the French Pediatric Society registry. A standardized survey was sent by e-mail to these pediatricians. We considered a hospital as responding when at least one

pediatrician filled out the survey. Interviewed pediatricians had either a permanent position in hospitals (“praticiens hospitaliers” or “professeurs”, denoting tenured senior positions) or a fixed-term or temporary position (for 2 to 4 years, such as “chefs de Clinique” or “assistants”, denoting junior positions).

Data collection

The survey was filled out online via Google Document software. The first part addressed general data such as workplace (University hospital center (UHC), general hospital center (GHC)), practitioner’s status (junior or senior, hospital practitioner or professor if senior), age and gender, ward (or wards) in which the clinical activity was performed (PED, GPD, pediatric pulmonology unit ...), the existence or not of a PICU inside the hospital, and the availability of HFNC outside this unit.

The second part of the survey could be accessed only by pediatricians effectively using HFNC in bronchiolitis outside PICU. Several responses were possible for each question. This part focused on the retained criteria for HFNC initiation (when the Wang score was between 3 and 5? between 6 and 7? higher than 8? when the respiratory rate was between 40 and 60/min? between 60 and 69/min? higher than 70/min? when the pulsed oximetry was below 92%? when the respiratory accessory muscles were used? when the child presented with one episode of apnea? two episodes of apnea? three episodes of apnea per hour? when the carbon dioxide rate was normal? higher than 45 mmHg? higher than 60 mmHg? when the cardiac beats were higher than 160 per min? when feeding difficulties appeared? with no specific criteria but just because HFNC was felt as necessary (subjective opinion)? others reasons?). Free comments were allowed. Initial settings for the HFNC were sought for (2 L/kg? 3 L/kg? to obtain which pulsed oximetry value?). Another question looked at the discontinuation criteria (when the Wang score was less than 8? 6? 3? when the respiratory rate was lower than 60/min? 40/min? when the respiratory accessory muscle utilization disappeared? when the pulsed oximetry was higher than 92%? 94%? when apnea disappeared? when the cardiac beats were normal? when the gas exchanges were normalized? when the feeding capacity was higher than 50% of the usual needs? normal? when you thought it was time (subjective opinion)? other reasons? and free comments). Associated nutritional mode, established surveillance mode, PICU transfer criteria, and eventually, practitioners’ subjective opinion on the benefit of using HFNC in PGD/PED were investigated. We also asked for the different medical reasons justifying an admission into a PICU. A total of four reminder e-mails were necessary to get answers from at least one practitioner per hospital.

Statistical analysis

Frequencies in number and percentage were calculated for all evaluated criteria. Responses were compared using a chi-2 test or Fisher’s exact test between hospital status (UHC/GHC), and between pediatricians of the hospitals using HFNC outside PICU. A *p* value less than 0.05 was considered statistically significant. Statistical analysis was carried out using SPSS.

Results

Characterization of the responder hospitals

The survey was completed by 135/166 (81.3%) selected hospitals, of which, 96 were GHC and 39 UHC (Fig. 1). Nearly all French regions, and all UHCs and big cities were represented. PICU was present in 74 of these 135 centers (54.8%). Seventy-two hospitals used HFNC outside PICU (53.3%), mostly GHC (59.4% vs 38.5% in UHC). HFNC was principally used in PGDs (*n* = 54; 75%), followed by PEDs (*n* = 9; 12.5%), pediatric pulmonology departments (*n* = 6; 8.3%), and short-term hospitalization departments (*n* = 4; 5.5%). Other noninvasive respiratory supports, especially C-PAP,

were available in 60 (83.3%) centers using HFNC (GHC 91%, UHC 53%, *p* = 0.002).

Characterization of the responder pediatricians

A total of 217 pediatricians filled out the first part of the survey, with 130 of them working in GHC (60%) and 87 in UHC (40%) (Fig. 1). Most of the responding physicians were hospital practitioners (*n* = 167; 76.9%) and held senior positions (*n* = 28; 12.9%). Population was primarily female (*n* = 145; 66.8%) with an average age of 35 years. Most worked in PGDs (*n* = 144; 66.4%) and in PEDs with a short-term hospitalization department (*n* = 83; 38.2%).

Half of these pediatricians (*n* = 109) used HFNC outside PICU.

Characterization of the initiation criteria for 109 pediatricians using HFNC outside PICU in bronchiolitis

The 2 main initiation criteria were rather subjective (Table 1). Pediatricians of UHC seemed to wait longer for objective criteria than their colleagues. Conversely, pediatricians of GHC were more sensitive to respiratory accessory muscle utilization and hypoxemia.

Characterization of the HFNC initial settings and mode of feeding and monitoring of the treated children

Initial settings included a flow of 2 mL/kg/min with an inspired fraction of oxygen allowing the pulsed oximetry value to be between 94 and 98%. Main associated nutritional modes were continuous enteral nutrition (*n* = 55; 51.9%) or intravenous hydration (*n* = 53; 50%). Monitoring was mainly conducted via a continuous cardiorespiratory monitor (*n* = 58; 80.6%) or continuous pulsed oximetry (*n* = 44; 61.1%), for some with a centralized control by nurses. Nursing staff was responsible for an average of 2.7 children on HFNC and monitored vital signs 8.6 times per day. There was no significant difference regarding those findings between UHC and GHC.

Criteria for PICU transfer when using HFNC for bronchiolitis

Main criteria for transfer to PICU were intense respiratory accessory muscle utilization (*n* = 71; 65.1%), carbon dioxide > 60 mmHg (*n* = 75; 68.8%), physician’s subjective assessment (*n* = 55; 50.5%), and occurrence of 3 apnea episodes in 1 h (*n* = 49; 45%). There was no difference between pediatricians of GHC and UHC.

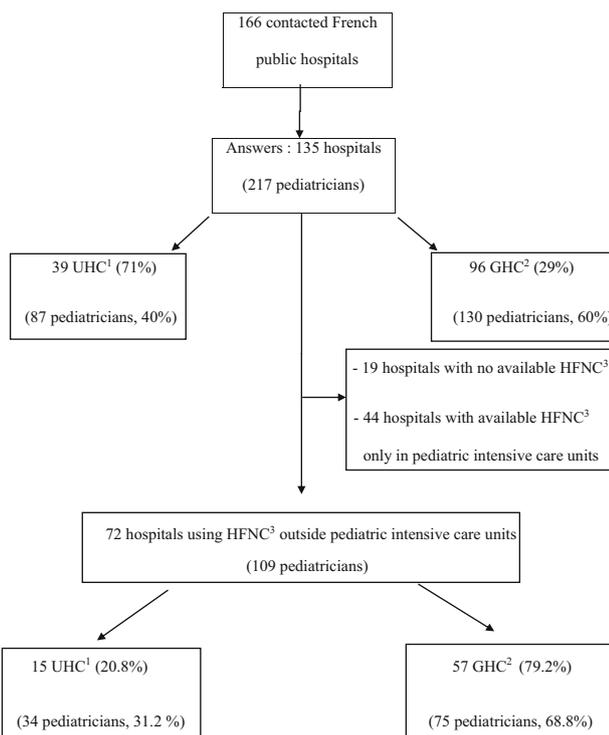


Fig. 1 Flowchart of a survey study distributed to 166 French hospitals regarding HFNC use in infant acute bronchiolitis ¹GHC, General hospital center; ²UHC, university hospital center; ³HFNC, high-flow nasal cannula.

Table 1 Withheld indications for high-flow nasal cannula instauration by 109 pediatricians using them outside pediatric intensive care unit for the medical care of infant acute bronchiolitis

HFNC initiation criteria	Responders <i>n</i> = 109	GHC <i>n</i> = 75	UHC <i>n</i> = 34	<i>p</i>
Respiratory accessory muscle utilization, <i>n</i> (%)	75 (68.8)	58 (77.3)	17 (50.0)	0.005
Subjective opinion, <i>n</i> (%)	65 (59.3)	42 (56.0)	23 (67.6)	0.17
Carbon dioxide > 60 mmHg, <i>n</i> (%)	46 (42.2)	27 (36.0)	19 (55.9)	0.04
SpO ₂ < 92%, <i>n</i> (%)	46 (42.2)	41 (54.7)	5 (14.7)	0.00
Respiratory rate > 60/min, <i>n</i> (%)	43 (39.4)	32 (42.7)	11 (32.4)	0.21
Respiratory rate > 70/min, <i>n</i> (%)	42 (38.5)	23 (30.7)	19 (55.9)	0.01
Carbon dioxide > 45 mmHg, <i>n</i> (%)	35 (32.1)	28 (37.3)	7 (20.6)	0.06
Apnea ≥ 2, <i>n</i> (%)	28 (25.7)	18 (24.0)	10 (29.4)	0.35
1 apnea, <i>n</i> (%)	24 (22)	19 (25.3)	5 (14.7)	0.16
Wang score ¹ ≥ 8, <i>n</i> (%)	23 (21.1)	17 (22.7)	6 (17.6)	0.37
Wang score 6–7, <i>n</i> (%)	19 (17.4)	14 (18.7)	5 (14.7)	0.59
Other criteria, <i>n</i> (%)	69 (63.3)			

¹ Wang score: clinical score of gravity in acute bronchiolitis

² SpO₂ pulsed oximetry

HFNC, high-flow nasal cannula; GHC, general hospital center; UHC, university hospital center

Characterization of the HFNC discontinuation criteria

HFNC discontinuation criteria are presented (Table 2). Pediatricians in GHCs waited longer for the disappearance of respiratory accessory muscle utilization and a correct feeding than their colleagues to stop HFNC.

Free comments concerning the use of HFNC outside PICU

Most of the physicians had a positive opinion on HFNC. Among responders, a majority (*n* = 92/104; 88.5%) thought HFNC improved infants' symptoms and comfort. Almost 2/3 (*n* = 69/104; 66.3%) considered that the use of this device should be widely developed in pediatric departments. Only 43 pediatricians responded to the last question: 11 (25.6% of responders) suggested HFNC should be used in units close

to PICU while waiting for emergency medical service or a transfer to PICU; 14 (32.6%) underlined a lack of formation on HFNC among nursing staff, insufficient number of nurses available for ensuring a safe use of HFNC, absence of written initiation, and discontinuation protocols; and 18 (41.9%) thought HFNC were easy to use, with an impression of reduction of PICU transfer rate.

Discussion

In this observational study, we found that HFNC were used for treating bronchiolitis outside PICU in more than half of the French public hospitals, particularly, in general hospitals with no PICU. Specific criteria for HFNC initiation and discontinuation clearly differed among practitioners and were highly subjective.

Table 2 Withheld indications for high-flow nasal cannula withdrawal by 109 pediatricians using them outside pediatric intensive care unit for the medical care of infant acute bronchiolitis

HFNC withdrawal criteria	Responders <i>n</i> = 109	GHC <i>n</i> = 75	UHC <i>n</i> = 34	<i>p</i>
Diminution of respiratory accessory muscle utilization, <i>n</i> (%)	69 (63.3)	46 (61)	23 (67)	0.34
Subjective opinion, <i>n</i> (%)	57 (52.3)	37 (49.3)	20 (58.8)	0.24
Normal gaseous exchanges, <i>n</i> (%)	47 (43.1)	37 (49.3)	10 (29.4)	0.04
Apnea disappearance, <i>n</i> (%)	46 (42.2)	36 (48)	10 (29.4)	0.05
Respiratory rate < 60/min, <i>n</i> (%)	32 (29.4)	21 (28)	11 (32.4)	0.04
SpO ₂ ¹ > 92%, <i>n</i> (%)	26 (23.9)	18 (24)	8 (23.5)	0.58
Respiratory accessory muscle utilization disappearance, <i>n</i> (%)	24 (22)	23 (30.7)	1 (2.9)	0.001
Feeding > 50% of normal supply, <i>n</i> (%)	22 (20.2)	20 (26.7)	2 (5.9)	0.009
Other criteria, <i>n</i> (%)	81 (74.3)			

¹ SpO₂ pulsed oximetry

HFNC, high-flow nasal cannula; GHC, general hospital center; UHC, university hospital center

According to the literature, from retrospective studies, HFNC would allow a reduction in intensive care transfer rate [9, 10, 16], intubation rate [8, 17, 26], survival rate [27], oxygen therapy duration [6, 16, 19, 27], and hospitalization duration [6, 10, 17, 26] in infant's bronchiolitis. An early use of HFNC would also cut the cost of pediatric global medical care [5, 12]. On the other hand, in 2 recent randomized controlled trials including more than 1500 infants, the results were less convincing with a duration of oxygen therapy and a duration of hospital stay similar between children treated with HFNC and those receiving standard oxygen therapy [7, 15]. With more than half of interviewed hospitals using HFNC outside PICU in bronchiolitis, it seems that French hospital practitioners are globally convinced by HFNC. However, the number of users is lower than that in Finland where HFNC were used in 85% of pediatric departments from 17 hospitals during the 2015–2016 epidemic period (mean incidence of HFNC treatment in infants aged of less than 1 year: 3.8 per 1000 per year) [24]. Other data from an inquiry led in the UK within a more global study called NOVEMBR are yet to be published [25]. In our study, HFNC use is shown to be more frequent in GHC than in UHC, possibly aiming at offsetting the absence of PICU. The increased number of C-PAP in GHC is likely due to the same reason. It was not possible to assess through the present study whether the use of HFNC modified the criteria of transfer to PICU compared with hospitals with no HFNC.

Our results clearly show that there is a lack of consensual criteria for the initiation and discontinuation of HFNC in bronchiolitis. Pediatricians working in UHC, equipped with a PICU, clearly wait for objective criteria such as an elevated respiratory rate or carbon dioxide rate, while pediatricians of GHC seem to initiate more quickly HFNC when confronted to signs of respiratory distress and abnormal pulsed oximetry. Overall, for most practitioners, HFNC initiation criteria rely on the physician's subjective opinion. Carbon dioxide value higher than 60 mmHg only comes in the third position while several studies show that a high carbon dioxide value at HFNC initiation was the major HFNC failure predictive factor [1, 14]. This is a strong argument in favor of HFNC early use, prior to major respiratory accessory muscle utilization. An initial flow of 2 mL/kg/min seems to be commonly admitted. A physiological study published in 2013 shows that a flow superior or equal to 2 mL/kg/min is associated to a pharyngeal pressure superior or equal to 4 cmH₂O with a sensibility of 67% and a specificity of 96% [20]. Another author demonstrates there is no difference in treatment failure rates between 2 and 3 mL/kg/min flow, but that 2 mL/kg/min flow tolerance is better and allows a quicker withdrawal of the device [21]. HFNC does not seem to forbid oral feeding or nasogastric feeding tube use in our medical practice.

Finally, discontinuation also varies interindividually among pediatricians, with a possibly longer duration of treatment for pediatricians of GHCs who seem to wait for a more complete respiratory normalization of the infant.

Whereas pediatricians using HFNC have a rather positive opinion on this device, our study shows they are still aware that this treatment requires proximity to intensive care unit. They are relatively uneasy on HFNC initiation or withdrawal criteria. The lack of written protocols on HFNC use in bronchiolitis, as reported by some interviewed practitioners, is certainly an explanation to these difficulties. In fact, the mere availability of instructions on HFNC settings clearly improves medical care and is associated with earlier HFNC withdrawal [24]. On the other hand, infants' monitoring under HFNC in pediatric units outside PICU needs to be improved. Indeed, efficiency in respiratory rate [3, 16], pulse rate [6, 13, 16], and clinical respiratory distress scale [9] seems to be brought out right from the first hour [21], with failure observed during the first 24 h [21]. Our study found that in practice, surveillance is mainly conducted via centralized monitoring. Nurses have an average of 2.7 infants to take care of and check constant 8.6 times per 24 h, even if this answer is to be taken cautiously, since given by physicians and not directly by the nursing staff. This clearly questions the need of an increase of numbers of paramedical staff during the epidemic period when using HFNC in bronchiolitis. However, a recent review [18] reports very few incidents, suggesting that HFNC are a relatively safe, well-tolerated, and easy to use method.

Conclusion

Our study shows a transfer of HFNC use outside PICU in pediatric hospitals, particularly, in the general hospitals. Practitioners are convinced of the efficiency of this device and willing to extend its use. Meanwhile, it is necessary to associate this extended prescription with staff training, to establish clear recommendations regarding a safe medical care and to validate guidelines for their use.

Authors' contributions MP, CF, ES, and JCD conceived the study and designed the trial. JCD and EB supervised data collection. ST provided statistical advice on study design and analyzed the data. MP and CF drafted the manuscript, and all authors contributed substantially to its revision. JCD takes responsibility for the paper as a whole.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval For this type of study, formal consent and ethics committee are not required.

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