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Research paper

Acute bronchiolitis: Experience of home oxygen therapy in "Hospital at Home" care from 2012 to 2014
Home oxygen therapy in "Hospital at Home" for bronchiolitis

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ABSTRACT

Aim: To describe the management of home oxygen therapy for infants with acute bronchiolitis through a home care network: Hospital at Home (HAH).
Methods: A retrospective observational study was carried out during two consecutive winters from 2012 to 2014.
Results: A total of 141 patients were eligible for home oxygen therapy, and 54 were discharged on home oxygen therapy through HAH. The median age of patients was 2.5 months (0.75–13 months). The average length of hospital stay before discharge was 4.9 days (1–17 days). In total, 73% of the children received oxygen at home. There was an average of five nurse visits per patient. Each child was seen by a pediatrician during the HAH care. There were no deaths or readmissions to an intensive care unit. There were two conventional readmissions for increased respiratory distress and two emergency department visits. The median length of HAH was 6 days (1–33 days).
Conclusion: Home oxygen for infants with acute bronchiolitis is a promising and safe alternative to reduce conventional hospitalizations. It is necessary to evaluate the cost of this treatment and its impact on nosocomial infections.

1. Introduction

Acute bronchiolitis (AB) is responsible for a high morbidity during the first 2 years of life. It is the leading cause of hospital admissions for infants in developed countries. In France, 460,000 children aged under 2 years are diagnosed with bronchiolitis each year, representing 30% of the children in this age group [1]. Of these children, 3–5% are hospitalized [2]. The hospitalization rate depends on the country and the year: It was 21.7 per 1000 infants in Norway in 2004 [3] and 31.2 per 1000 in the United States in 1999 [2,4]. In France, 29,784 infants were hospitalized in 2009, corresponding to a hospitalization rate of 35.8 per 1000 [5]. An increasing hospitalization rate has been observed since 1999 [2,6,7].

Every winter, the overlapping epidemics of gastroenteritis (GE) and AB overload pediatric units. Young children hospitalized with AB are at high risk for nosocomial GE, and this risk is proportional to the length of stay [8]. Changes in medical practice are being introduced in some countries, aiming to reduce the hospitalization rate as well as the duration and cost of hospitalization for AB. New guidelines have recently been published on the use of home oxygen therapy (HOT) for chronic lung diseases but none for acute respiratory diseases, such as bronchiolitis [9,10].

In five studies conducted in the United States and Australia, the use of home oxygen therapy (HOT) for some children with AB appears to be an interesting alternative to traditional hospitalization [11–15]. To our knowledge, HOT for infants with AB has not been reported in Europe to date [16].

The primary objective of this pilot study was to determine the safety of HOT for children with AB. The secondary objectives were to

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assess (1) the effectiveness of this management and (2) the parents' satisfaction with continued HOT for their child.

2. Patients and methods

We conducted a retrospective pilot study over two consecutive winters, between November 2012 and February 2014, of children treated in the Hospital at Home (HAH) care for AB from the Robert-Debré Hospital (APHP, Paris). This is a 498-bed urban tertiary care teaching hospital in Paris, France, which in 2013 and 2014 cared for, respectively, 73,390 and 77,238 pediatric emergency patients. Infants hospitalized for AB are admitted through the emergency department, mostly to the general pediatrics department but also to a neonatology unit dedicated to these infants.

Eligible patients were children under 2 years of age, mostly hospitalized in general pediatrics or neonatology for AB or infant's asthma and requiring oxygen therapy due to hypoxia. According to the French recommendations published in 2000, the diagnosis of bronchiolitis was made for the first two episodes of wheezing in a child under 2 years of age and the diagnosis of infant's asthma from the third episode of wheezing in the same age group [17]. Hypoxia was defined as oxygen saturation under 94% on air and at rest or during bottle feeding [17]. More recent recommendations in 2013 advise starting oxygen therapy if saturation is less than 92% to achieve target values of SpO_2 over 94% during wakefulness and over 91% during sleep [18]. In this study, the choice was made to define hypoxia as an oxygen saturation of less than 94% in the awake state and less than 92% in the sleep state.

If the inclusion criteria were met (Table 1), information was given to the parents on the organization of the HAH. If the parents agreed, the child was discharged from the hospital on the same day and returned home by ambulance, while the HAH organized the delivery of the equipment (continuous pulse oximetry, oxygen, etc.) and the first HAH nurse visit at home. Parents were then given complementary information on the use of HOT and on how to monitor their child for signs of clinical deterioration. HAH consisted of a daily HAH nurse visit and at least one pediatrician visit per stay. The HAH phone number was provided to the parents and a pediatrician was available 24 h a day.

Criteria for hospital readmission were (1) oxygen requirement increased to more than 1 L/min to maintain SpO_2 greater than 94% while awake and 92% while asleep, (2) apneic episode, (3) poor feeding defined by less than 50% of the usual oral feeding intake due to increasing respiratory distress, or clinical signs of dehydration.

The safety of this protocol of care was defined as (1) no hospital readmission after discharge, (2) no transfer to the intensive care unit, and (3) no serious complications (respiratory arrest, apnea, cyanosis). HAH management was stopped when the child no longer required oxygen therapy for at least 24 h, with SpO_2 being greater than or equal to 92% while sleeping and greater than or equal to 94% while awake and when the child no longer required home care or monitoring.

The data were collected from the medical records of patients at the HAH. Parental satisfaction was measured by a standardized questionnaire at the end of care.

The study was approved by the Robert-Debré Hospital Ethics Committee (number 2015/196) and has been reported to the *Commission Nationale de l'Informatique et des Libertés* (CNIL), registered on September 15, 2014 (declaration no. 1794021 v. 0).

3. Results

A total of 471 patients were hospitalized for AB during the two study periods, from 6 November 2012 to 11 February 2013 and from 16 October 2013 to 20 February 2014. Of these infants, 11.5% (n=54) were admitted to HAH. These patients came from the general pediatrics department (n=50), emergency unit (n=3), and neonatology department (n=1).

3.1. Demographic and clinical characteristics of patients

The characteristics of patients in HAH care are reported in Table 2. The population included two former extreme preterm infants (born at a gestational age of 25 and 26 weeks of amenorrhea). One child was hospitalized twice, at 7 and 9 months of age. Three children had a significant past medical history of hypertrophic heart disease, pulmonary valve dysplasia, and anemia at 9.2 g/dL. Patients treated with nebulization of β2 mimetics and inhaled corticosteroids had bronchopulmonary dysplasia (n=3) or had been hospitalized with significant bronchial spasticity (n=4).

3.2. Safety of care in HAH

There were no calls to the emergency medical services from home and no secondary transfer to the ICU. Two children (4%) were referred to a doctor in the emergency department: one for acute otitis media and one for a mild fever. Two other children (4%) were readmitted for conventional hospitalization due to increased signs of respiratory distress: a 5-week-old infant who had been transferred to HAH from the emergency department, and a 2.5-month-old infant in a context of misunderstanding of medical instructions by the parents (24 h and 4 days after transfer to HAH, respectively) (Fig. 1).

Some logistical problems were encountered: delay in home oxygen delivery (n=3) and delay in ambulance transport (n=2).

3.3. Reasons for non-inclusion of patients with acute bronchiolitis in the HAH care circuit

The reasons for non-inclusion of patients with AB in the HAH care circuit were collected during the 2013–2014 season and involved 87 children: 34 children (39%) were living outside the north-east HAH sector, the parents of 19 children refused HAH care (22%), there was no availability of HAH for two children (2.3%), 31 children were not admitted for medical reasons (35.6%), and with one child there was a lack of parental understanding. The medical reasons not allowing transfer to HAH were concomitant GE (n=2), child younger than 3 weeks (n=3), duration of monitoring less than 24 h (n=2), or stopping oxygen therapy before the child was transferred to HAH (n=4). Parental refusals were mostly related to a lack of space and/or the presence of other children at home.

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
- Clinical diagnosis of bronchiolitis	- History of apnea
- Age less than 2 years	- Fever when discharged in HAH
- Food ration greater than 50% taken by mouth	- Parental opposition
- Loss of weight ≤ 5%, without nutritional support (enteral or parenteral)	- Parental psychosocial reasons
- Stabilization in a classic unit of hospitalization ≥ 24 h	- Home out of the area covered by HAH or no more "beds" available in HAH
- Adequate oxygenation (≥ 94% while awake and/or ≥ 92% while asleep) on ≤ 1 L/min of oxygen	

HAH: Hospital at Home.

Table 2
Demographic and clinical characteristics of patients, care given, and safety and efficacy of care support in HAH.

	Discharged to HAH (*n*=54)	Percentage (%)
Age (months)		
Median (range)	2,5	
Range	0.75–13	
Sex		
Boy	30	56.0
Gestational age at birth (weeks of amenorrhea)		
> 37	50	92.6
32–37	1	1.9
< 28	3	5.6
Initial hospitalization department		
Emergency	3	5.6
General pediatrics	50	92.6
Neonatology	1	1.9
Length of initial stay in the department (days)		
Median	4	
Range	1–17	
Nasal canula oxygen therapy	41	76.0
Inhaled treatments		
Hypertonic saline serum	28	52.0
B_2 mimetics	7	13.0
Corticosteroids	3	6.0
Antibiotics	6	11.0
For a pulmonary infection or atelectasis	5	9.0
For an other infection	1	2.0
Number of medical visits		
Median	1.5	
Range	1–5	
Number of nurse visits		
Median	5	
Range	5–22	
Emergency department visit	2	4.0
Readmissions	2	4.0
Logistical problems	5	9.0
Length of stay in HAH (days)		
Median	6	
Range	1–33	

HAH: Hospital at Home.

3.4. Parental satisfaction at the end of HAH stay

Parental satisfaction was studied for the 2013–2014 season and involved 33 patients treated with HAH. Only the non-anonymous questionnaires could be analyzed, i.e., 20/33 (60.6%). Analysis of the questionnaires showed an average of 3.85/4 for the overall assessment at the end of the HAH stay for AB. The average score for logistics was 3.4/4 and the remarks were mainly related to the equipment and its delivery (7/20 patients, i.e., 35%). Parents were generally satisfied with the information given as well as with the organization and the course of care (3.75/4). A total of 70% of parents needed to contact HAH during the day (14/20 parents) and 40% at night (8/20 parents).

4. Discussion

There is little experience reported in the literature on the management of HOT for infants with AB. Pediatric teams in the Denver area have been providing HOT for AB since 1998 and have the greatest experience [12–14]. Patients in the Denver study were transferred directly from the emergency department, after an observation period ranging from 4 h to 24 h [12,15]. Criteria for home oxygen discharge were comparable in the different reported experiences. Only the duration of monitoring, patient age, and oxygen saturation requiring oxygen therapy varied between studies.

The natural course of bronchiolitis is progressive with a worsening occurring 2–4 days after the onset of dyspnea [19]. The risks are

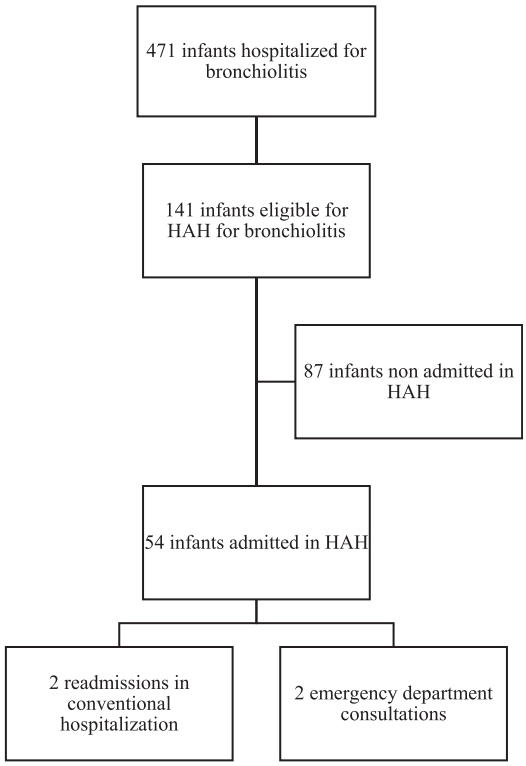

Fig. 1. Flow chart (for both seasons: 2012–2013 and 2013–2014)
HAH: Hospital at Home.

respiratory deterioration or the onset of apnea in some cases requiring a transfer to the ICU for ventilatory support. These complications occur more frequently in very young infants aged less than 3 months with a history of prematurity and underlying cardiac or respiratory pathology [20]. Thus, Joseph et al. warn against discharging infants with bronchiolitis too early because of the possibility of apnea, which may put them at risk [21] Patients selected for home discharge on oxygen should therefore be as stable as possible from a safety perspective [22], which is assessed in all studies by the rate of readmission and/or reconsultation in the emergency department [11–15]. Readmission rates after home oxygen discharge ranged from 4.3% [11] to 9.4% [12].

In our study, patients were monitored during an initial conventional hospitalization before transfer to HAH to ensure stability and safety. The children were discharged after a conventional hospital stay of at least 24 h (median 4 days). Home care was then supervised by the pediatric HAH paramedical team, who are trained in the management of these infants in respiratory distress and able to educate parents to watch for signs of respiratory distress and to give an alert if necessary. In our study, the infants were very young (median age 2.5 months; 3 weeks to 13 months).

This organization enabled the pursuit of oxygen therapy in the homes of very young infants and those with a medical history (prematurity, underlying cardiac or respiratory pathology). In other published studies, patients managed with HOT for HAH were older, ranging from 7.3 months [11] to 10 months [12]. In these studies, the minimum observation time in the emergency department was 4 h [12], 8 h [11,13,14], or 24 h [15]. In our experience, only two infants discharged in HAH had to be readmitted for conventional hospitalization (4% of patients). Three infants (5.6%) had been transferred to HAH directly from the emergency department with less than 24-h monitoring; one of them was readmitted to hospital for worsening of respiratory distress. This direct transfer from the emergency department was then abandoned, as it was deemed dangerous due to the short duration of surveillance. Two of the studies conducted in

Denver showed a readmission rate of 9.4% and 6%, for patients from the emergency department who were managed at home with oxygen, with fever being the predictor of readmission [12,14]. In the study by Flett et al., patients returned home on oxygen after 4 h of monitoring in the emergency department, and most of the causes of readmission (9.4%) involved aggravation of bronchiolitis (73% for increased respiratory work, 45% for increased oxygen requirements, 5% for rehydration) [12]. Freeman et al. in a prospective study showed the safety of outpatient HOT, with 4.9% of readmissions in a high-altitude setting [23].

HAH management of infants with bronchiolitis reduces the length of hospital stay. Tie et al. and Sandweiss et al. reported a reduced length of stay in the home oxygen group of, respectively, 55.2 vs. 96.9 h [15] and 49.3 vs. 63.3 h [11]. Moreover, with the implementation of a care circuit directly from the emergency department, Halstead et al. showed a reduction in admissions for conventional hospitalization for bronchiolitis of 40−31% with a readmission rate of 6% [14]. In our study, the median length of stay in HAH was 6 days (1−33 days), 3 days longer than the average length of stay for bronchiolitis found in the literature [5,11,24]. It ranged from 1.8 to 6 days in other studies [11−15]. Che et al. analyzed hospitalizations in acute care services (resuscitation, continuing care unit, neonatology) for bronchiolitis in France in 2009 [5]. The median length of stay was 4.6 days for all hospitalizations, with a median patient age of 107 days. The vast majority (74%) of patients hospitalized in acute care units were younger than 3 months (median age 42 days) and these children were hospitalized, on average, for 9.7 days. This is consistent with the 2014 study by Flett et al. in the United States [12], who showed that a long duration of oxygen therapy was associated with an age of less than 6 months and a gestational age of less than 37 AS. Thus, in infants younger than 6 months, the duration of oxygen therapy was 9 days [12]. Our long lengths of stay are probably related to the young age of children treated with HAH for bronchiolitis (median age 2.5 months).

The main cause of hospitalization for bronchiolitis and its prolongation is hypoxia. In two studies conducted in the United States, hypoxia prolonged hospitalization by 1.6 days [11,12]. The definition of hypoxia varies from country to country. In the United Kingdom, oxygen is administered to achieve an SpO_2 of between 92% and 95% [25]. The American Academy of Pediatrics recommends an SpO^2 of more than 90% in children with no underlying respiratory pathology [26]. This threshold has been respected in American studies, except for the Sandweiss et al. study where the threshold is 88% [11]. The French consensus conference of 2001 defined a threshold of SpO_2 of less than 94% for the initiation of oxygen therapy [19]. The 2019 French HAS bronchiolitis guidelines recommend the use of oxygen if SpO_2 is 92% or less, with a target value of SpO_2 greater than 92% in the awake state and greater than 90% during sleep [27].

Oxygen withdrawal modalities can prolong the duration of oxygen therapy and hospitalization. It should be noted that oxygen withdrawal modalities are not specified in any recommendations for acute respiratory diseases. The only study that provides an explanation of oxygen withdrawal is that of Tie et al. [15].

Another interesting aspect of HOT is the reduction in the cost of bronchiolitis management. Sandweiss et al. reported that this method of management reduces hospitalization costs and length of stay [11]. HOT may also reduce the incidence of nosocomial GE occurring during conventional hospitalization of these young infants with bronchiolitis. Indeed, in France, winter is marked by the overlap of two epidemics of bronchiolitis and GE responsible for many infant hospitalizations. Nosocomial rotavirus GE mainly affects children under 5 months of age and extends their hospitalization by an average of 5 days [28].

In 2001, Labbé argued that the risk/benefit ratio was not favorable toward HOT for AB because of the difficulties of (1) having a technician, nurse, and doctor available 24 h a day and (2) educating parents to monitor their child at home [29]. In 2009, following the studies published on the subject, particularly those by Tie et al. and Bajaj et al., Cunningham reiterated the questions that need to be asked about the efficiency of this care and support in his article titled "A hospital is no place to be sick" [30]. Currently, HAH appears to meet the necessary conditions for the safety and effectiveness of this type of care. Indeed, the selection of patients requiring oxygen therapy for AB and the rigorous preparation of their discharge from HAH allow for the optimal care of these children with great safety and family satisfaction. One of the main limitations of this work is that all the children were recruited from a single hospital, but the good results of the first 2 years of this study have led to a wider inclusion of patients from other hospitals and pediatric services in Paris and Ile de France.

5. Conclusion

Our pilot study shows that HAH for AB is a promising and safe alternative to a prolonged conventional hospitalization for patients, provided that these patients are selected well and stable. New modes of management must be undertaken, in view of the frequency of bronchiolitis in infants, which is responsible for the overload of pediatric services during the autumn−winter epidemic season. A medico-economic study of the impact of HAH on the cost of AB would further define the appropriateness of this kind of management.

Conflicts of interest

None.

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