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Research Article

The use of Heliox in Hospitalized Children from Cartagena, Colombia: a Case Series

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Abstract

Objective: To describe a case series of patients at risk of acute respiratory failure, who were managed with Heliox.

Methods: A descriptive, retrospective and cross-sectional study about the use of heliox in pediatric patients at risk of respiratory acute failure, admitted to the pediatric health center "Hospital Infantil Napoleón Franco Pareja" from Cartagena, Colombia. Differences in categorical variables were analyzed by chi-square or Fisher exact test.

Results: Fifty two patients were included. The mean age was 21.2±56 months. The two most frequent diagnoses were *status asthmaticus* (38.5%) and acute bronchiolitis (26.9%). Success of heliox therapy was 76.9%. The route of administration was not related to the type of response. The duration of heliox therapy was in average 5.9 hours (SD±4.1), in patients who did not respond favorably to heliox, and 8.0 hours (SD±5.6) in those who did respond.

Conclusion: A high success rate with heliox therapy was found in this case series. Its use is recommended as an adjunct therapy in the management of acute respiratory insufficiency.

Keywords: Heliox therapy; Bronchiolitis; Asthma; Acute Respiratory

Abbreviations

ICU: Intensive Care Unit; SD: Standard Deviation; OI: Orotracheal Intubation

Introduction

In the last decades, the helium-oxygen mixture (heliox) has been used as a treatment for several respiratory disorders, including acute upper and lower airway obstructive conditions. In the pediatric field, it has gained relevance as a treatment for asthma, bronchiolitis and croup [1]. Helium was introduced in the medical practice in the 30's decade by Barach. He demonstrated that, in combination with oxygen, the resulting mixture improved airflow in patients with laryngeal, tracheal or lower airway obstructive problems [2]. However, in spite of its benefits, its use was rapidly replaced by bronchodilators [3].

Helium is a colorless, inodorous, tasteless and inert gas with low density. Combined with oxygen, the density of the resulting mixture is three times lower than air; this leads to a less turbulent airflow and a reduction in resistance to gas flow and work of breathing [4]. Furthermore, diffusion of carbon dioxide through helium is four to five times faster than through air, which improves ventilation and carbon dioxide removal. Heliox does not have a pharmacological effect on its own; however, it may act as a therapeutic carrier, retarding muscular fatigue, respiratory failure and avoiding the use of more aggressive treatments. Few secondary effects have been reported for heliox use, which is mainly due to the lack of potential biological interactions.

In this study, we describe a case series of patients, mostly with broncho-obstructive conditions, who were treated with heliox to prevent acute respiratory failure, hospitalized in the medical institution "Hospital Infantil Napoleón Franco Pareja" from Cartagena, Colombia.

Methods

A descriptive, retrospective and cross-sectional study about the use of heliox in pediatric patients, admitted to the Hospital Infantil Napoleón Franco Pareja from July 2012 and April 2013. All patients who received heliox therapy, admitted to the pediatric intensive care unit (ICU) or Emergency room service, were included in the study. In our institution, heliox was administered to those patients at risk of acute respiratory failure or as part of an extubation protocol to prevent reintubation. Heliox was used as a carrier of drugs administered by inhaled route. Response to heliox treatment was measured as the prevention of intubation or re-intubation.

Administration of heliox

Inhaling mask: Heliox mixture was composed of helium at 70% and oxygen at 30%. For administration, the patient was placed in prone position; vital signs were monitored. The mask was attached to heliox cylinders through the use of hoses. Heliox was administered at 6-8 L/min, regulated by a valve connected to a pressure gauge.

Non-rebreathing mask or nasal cannula: After observing a good response with inhaling mask, heliox was then administered through a non-rebreathing mask at 8/10 L/min. In some cases, heliox was administered by nasal cannula at 2 L/min (determined by comfort, the size of the patient, and at the discretion of the physician).

Data collection and processing: Data were tabulated in a

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Table 1: Descriptive features of patients.

Features n (%)	Female	Male	Total
Age in months			
< 12	7(13.5)	21(40.4)	28(53.8)
12 – 24	5(9.6)	7(13.5)	12(23.1)
25 – 60	4(7.7)	2(3.8)	6(11.5)
> 61	5(9.6)	1(1.9)	6(11.5)
Diagnosis at admission			
Bronchopneumonia	0 (0.0)	4 (7.7)	4 (7.7)
Bronchiolitis	5 (9.6)	9 (17.3)	14 (26.9)
Drugpoisoning	1 (1.9)	0 (0.0)	1 (1.9)
Status asthmaticus	8 (15.4)	12 (23.1)	20 (38.5)
Epidural haemorraghe	1 (1.9)	0 (0.0)	1 (1.9)
Hydrocephalus	0 (0.0)	1 (1.9)	1 (1.9)
Acuteleukemia	1 (1.9)	1 (1.9)	2 (3.8)
Bacterialpneumonia	5 (9.6)	2 (3.8)	7 (13.5)
Congenitalheartdefects	0 (0.0)	1 (1.9)	1 (1.9)
Septic shock	0 (0.0)	1 (1.9)	1 (1.9
Hospital service			
Intensivecareunit	19(36.5)	25(48.1)	44(84.6)
Emergencyroom	2(3.8)	6(11.5)	8(15.4)
Total	21(40.4)	31(59.6)	52(100.0)

Microsoft Excel 2010 spreadsheet (Microsoft, Redmond, WA) and analyzed with the same software. Diagnosis at admission, age, gender, clinical evolution, length of hospital stay and discharge diagnosis were recorded. Regarding heliox therapy, the following information was analyzed: administration route, number of therapies, duration of heliox administration, therapy response and need of OI before or after heliox use. Descriptive information about these data was reported as the arithmetic mean and its standard deviation. Differences between proportions were analyzed by Pearson chi-squared test or Fisher exact test, when appropriate.

Results

Fifty two patients were evaluated in this case series; thirty one of them (59.6%) were males. Mean age was 21.2±SD 25.6 months (range: 0.5 months to nine years-old). Girls were significantly older than boys (33.1±28.2 vs. 13.2±20.5 months; $p<0.05$). The most common diagnoses were *status asthmaticus* and acute bronchiolitis (Table 1). Twenty patients had been intubated before heliox administration (38.5%). Mortality rate was 5.8% (n=3); death cases had already been intubated before heliox administration.

Heliox was used in combination with different drugs: adrenaline (50.0%), salbutamol (28.8%) or budesonide (21.2%). As observed in Table 2, response to treatment in the case series was 71.2%, and similar between patients who had been intubated or not before heliox administration ($p = 0.63$). Fifteen out of 20 patients (75.0%) with *status asthmaticus* did not receive orotracheal intubation (OI); from 14 patients with bronchiolitis, eleven did not require OI (78.6%). Administration route (Table 3) was neither associated to the successfulness of the therapy ($p>0.05$). There were not significant differences in the time receiving heliox in those patients who did not respond (5.9 h±4.1) compared to those responding to this therapy (8.0 h±5.6).

Table 2: Response to heliox treatment.

Disease	Response to Heliox n (%)[#]	Response rate (%)*
Intubated patients before Heliox		
Bronchopneumonia (n=1)	1 (100)	5.0
Bronchiolitis (n=7)	6 (85.7)	30.0
Status asthmaticus (n=5)	4 (80.0)	20.0
Epidural haemorraghe (n=1)	1 (100)	5.0
Hydrocephalus (n=1)	1 (100)	5.0
Bacterialpneumonia (n=4)	2 (50.0)	10.0
Septic shock (n=1)	0 (0)	0.0
Sub-total n= 20	**15**	**75.0**
Non-intubated patients before Heliox		
Bronchopneumonia (n = 3)	2 (66.6)	6.3
Bronchiolitis (n = 7)	5 (71.4)	15.6
Drugpoisoning (n = 1)	0 (0)	0.0
Status asthmaticus (n = 15)	11 (73.3)	34.4
Leukemia (n = 2)	2 (100)	6.3
Bacterialpneumonia (n = 3)	2 (66.6)	6.3
Congenitalheartdefects (n = 1)	1 (100)	3.1
Sub-total n= 32	**22**	**68.8**
Grand total (n=52)	**37**	**71.2[ϕ]**

Proportion of responders are shown relative to each disease condition[#], sub-totals* and to the complete case series[ϕ].

Discussion

This study describes the results about the use of heliox therapy in a case series of patients, most of them with different diagnosis of broncho-obstructive syndromes, who received heliox as part of a protocol to prevent acute respiratory failure. All patients were admitted in Hospital Napoleón Franco Pareja (Cartagena, Colombia). Response to treatment in the series was 71.2% similar to that obtained by Iglesias-Fernández et al. in Spain in a series of 54 patients with a response rate of 83.1% [5].

Effectiveness rate to heliox therapy seems to be determined by several factors, associated with the clinical evolution of the disease, time of intervention and intrinsic features of patients [6]. Differences in the efficacy and need for OI may be due to the early use of heliox and the severity of respiratory failure. Early use of heliox is associated to more efficacy [5].

Heliox benefits in the management of airflow obstruction associated-diseases depend on the physical properties of helium. This gas, which has very low density, permits a greater flow rate and higher carbon dioxide diffusion, compared to oxygen. It has lower turbulence; which could be advantageous for pediatric patient's ventilation, whose airways are narrower. Several studies support the use of heliox therapy in children with bronchiolitis [7-9]. However,

Table 3: Administration routes.

Route of administration	n(%)
Nasal canula	**6 (11.5)**
Bronchopneumonia	1 (1.9)
Bronchiolitis	3 (5.8)
Status asthmaticus	2(3.8)
Facial mask	**46 (88.5)**
Bronchopneumonia	3 (5.8)
Bronchiolitis	11 (21.2)
Drugpoisoning	1(1.9)
Status asthmaticus	18(34.6)
Epidural haemorraghe	1(1.9)
Hydrocephalus	1(1.9)
Acuteleukemia	2(3.8)
Bacterialpneumonia	7(13.5)
Congenitalheartdefects	1(1.9)
Septic shock	1(1.9)

another clinical trial did not find significant differences in the clinical evolution of treated patients [10]. Heliox may be useful in children with bronchiolitis and moderate respiratory failure, but its effect seems to be less relevant in severe cases.

A third part of these case series were patients with status asthmaticus, 75.0% of them did not require OI. These good results may be explained by the use of heliox, which has shown positive effects to ameliorate airflow obstruction in cases of asthma. Kudukis et al, in 18 pediatric patients with asthmatic status, showed that heliox use was associated to an improvement in paradojic pulse, peak flow and dyspnea; moreover, it avoided OI in the patients, whom it was planned for before treatment. Likely, in a randomized clinical trial where heliox therapy was compared to oxygen alone, improvements in airflow obstruction were obtained in lesser time (20 minutes) than by using oxygen alone (360 minutes) [11]. On the other hand, several studies, performed in children as well as in adults, have not shown effectiveness. Carter et al. evaluated in a cross-over, placebo controlled, randomized study heliox effectiveness for severe asthma treatment in pediatric patients, taking spirometric values as outcomes. No significant changes were found in these values after using heliox [12]. Some authors have argued that differences in the observed results depend on how the study population was selected, since it seems that heliox therapy is more useful in the most severe cases. For example, according to Kim et al. [13], spirometry performance suggests that recruited patients were not in a severe condition. Another application in the management of asthma, although it was not evaluated in this study, is using this gas to nebulize B_2 agonists [14].

Heliox therapy has shown to be safe in most studies, independently of its efficacy. Lack of side effects may be related to the absence of biological interactions. Hence, its use is recommended as an adjunct therapy in the management of obstructive related diseases, especially in the most severe cases, since it decrease the need of OI and improve clinical condition of patients [15].

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