EFFICIENCY OF OXYGEN THERAPY BY HEAD BOX FOR ACUTE RESPIRATORY FAILURE IN INFANTS

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ABSTRACT

Oxygen therapy is the main treatment method for acute respiratory failure in children. The method consisting in the administration of oxygen therapy by head box to infants is frequently used in pediatric practice.

Objectives. To evaluate the efficiency of oxygen therapy administered by head box to infants suffering from pneumogenic acute respiratory failure by comparing two methods for measuring hemoglobin oxygen saturation: in arterialized capillary blood and by pulse oximetry.

Material and method. 30 infants suffering from pneumogenic acute respiratory failure were studied. We used a clinical appraisal score for acute respiratory failure, which appraises respiratory rate, nasal flaring, recession, cyanosis, sensorial, before and after oxygen therapy. In arterialized capillary blood we measured partial pressure of oxygen and hemoglobin oxygen saturation, and we used an Automatic Blood Gas System analyzer. We also measured hemoglobin oxygen saturation using a pulse oximeter. Determinations were made before the initiation of oxygen therapy, and 30 minutes and 60 minutes after the initiation of oxygen therapy.

Results. As compared to the baseline values, determined before the initiation of oxygen therapy, we recorded a statistically significant improvement in the clinical score both after 30 minutes and 60 minutes from the initiation of oxygen therapy ($p<0.001$). The improvement was greater after 60 minutes. The increase in the partial pressure of oxygen was statistically significant both at the 30 minute and 60 minute determination ($p<0.001$). Both methods of SaO_2 measurement recorded statistically significant increases ($p<0.001$) in this variable after 30 and 60 minutes, respectively.

Conclusions. Oxygen therapy administered by head box improves acute respiratory failure appraised by clinical score. The administration of oxygen therapy by head box to infants significantly increases the values of partial pressure of oxygen and hemoglobin oxygen saturation measured in capillary blood, as well as the values of hemoglobin oxygen saturation determined by pulse oximeter both after 30 minutes and after 60 minutes. The increases in the three parameters are larger after 60 minutes. There is statistically significant concordance between the values of hemoglobin oxygen saturation determined in capillary blood and by pulse oximetry at all determinations.

Key words: partial pressure of oxygen, Astrup parameters, hemoglobin oxygen saturation, pulse oximetry

INTRODUCTION

Acute respiratory failure shows the incapacity of the respiratory system to oxygenate venous blood and eliminate carbon dioxide (1, 2). Its severity requires emergency therapeutic intervention (3). Respiratory diseases are still common in infants, and cause increased morbidity, and some-

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times even mortality (4). Respiratory infections predominate the etiology of acute respiratory failure (ARF) in infants, and the most common infectious agents are viruses, most often the respiratory syncytial virus, followed by bacteria (5,6).

Infants tend to show higher risk of ARF in different grades of severity (7). Besides etiologic treatment, in order to maintain adequate tissue oxygenation, infants with pneumogenic ARF also require pathogenetic treatment by oxygen therapy (7,8). The most common technique of oxygen administration to infants is by head box. The therapeutic response to oxygen therapy administration is appraised by measuring partial pressure of oxygen (pO_2) and monitoring hemoglobin oxygen saturation (SaO_2) (9,10,11).

The purpose of this study was to evaluate the efficiency of oxygen therapy by head box for pneumogenic ARF in infants.

MATERIAL AND METHOD

We studied a number of 30 infants with pneumogenic ARF, who received oxygen therapy by head box. The study was a prospective cohort study, and was conducted between October 2007 and December 2012 in the 3[rd] Pediatrics Department in Cluj-Napoca. The inclusion criteria were: infants suffering from pneumogenic ARF, diagnosed on the basis of clinical parameters (oxygen saturation measured transcutaneously by pulse oximeter and in arterialized capillary blood measured by an Automatic Blood Gas System). Informed consent was obtained from family members. Patients with chronic respiratory failure, cardiac pathology, genetic disorders and prematurity were excluded from the study. Oxygen was delivered at a flow rate of 10 liters / minute in the head box. Each case was evaluated by determining a clinical score (12,13), which appraised five parameters (respiratory rate, nasal flaring, recession, cyanosis, sensorial) according to intensity quantified as: absence (0), medium intensity (1), and severe intensity (2). We monitored partial pressure of oxygen and hemoglobin oxygen saturation (SaO_2) in arterialized capillary blood, which had been collected after prior extremity massaging (invasive method), and we used the Automatic Blood Gas System AVL 995 Analizer. Hemoglobin oxygen saturation was also measured (SpO_2) by a H100N pulse oximeter (noninvasive method), after a state of equilibrium had been reached. Measurements were conducted before, and 30 min and 60 min, respectively, after the initiation of oxygen therapy. ARF was classified according to the value of SaO_2 into grade I: SaO_2 = 90-92%, grade II: SaO_2 = 85-89%, and grade III: SaO_2 = 80- 84%.

Statistical analysis. The qualitative variables were summarized as percentage and the associated 95% confidence interval. The quantitative variables were summarized as mean ± standard deviation when normal distribution was not rejected statistically, and as median and variation interval given by the 25[th] percentile and the 75[th] percentile in the other cases. Two groups were compared by applying a Z-test for proportions in the case of qualitative variables, and by applying a Sign test for comparing two paired determinations, and a Friedman ANOVA test for comparing three paired determinations, respectively, in the case of quantitative variables for which the hypothesis of normal distribution was rejected. When comparing two groups we used a significance threshold of 5%, while when comparing three paired determinations we used a significance threshold of 1.667%. The Statistica (v.8) program was used for inferential statistical analysis, and the graphical representations were created in the Microsoft Excel program (14,15).

RESULTS

Thirty infants with acute respiratory failure were included in the study and the efficiency of oxygen therapy applied using head box was evaluated. Demographic and baseline characteristics of the sample are presented in Table 1.

TABLE 1. *General characteristics of subjects with acute respiratory failure included in the study*

Variable	Value	Statistics (p)
Age (months)[a]	3.60 ± 2.40	
Gender[b] Male Female	 56.67 (36.78-73.22) 43.33 (26.78-63.22)	-1.4745 (0.1403)
Area of origin[b] Rural Urban	 50.00 (30.11-69.89) 50.00 (30.11-69.89)	0.0000 (1.0000)
Birth weight (kg)[a] Male Female	 2.96 ± 0.22 3.00 ± 0.29	0.2276 (0.8216)
Current weight (kg)[a] Male Female	 5.66 ± 2.70 5.55 ± 2.90	-0.1779 (0.8601)
Height (cm)[a]	59.90 ± 5.94	
Ponderal index[c]	1.11 (1.00-1.20)	
Temperature on admission[c]	37.30 (37.00-38.00)	
Grade of ARF [b] I II III	 10.00 (3.44-26.56) 50.00 (30.11-69.89) 40.00 (23.44-59.89)	 7.303 (< 0.0001) I vs II -1.0954 (0.2733) II vs III 5.4772 (< 0.0001) I vs III

[a]mean±standard deviation;
[b]% (IC 95%), where IC 95% = 95% confidence interval; Z-test for comparing two proportions;
[c]median (Q1; Q3), where Q1 = 25[th] percentile, Q3 = 75[th] percentile;

Most frequent, the acute bronchiolitis (26 cases out of 30) was the cause of the ARF on the investigated sample (Fig. 1). The significant differences between two proportions according to etiology were as follows: acute bronsiolitis vs all others etiologies (the less significant Z statistics = -10.912, p < 0.0001), bronchopneumonia/bacterian pneumonia vs. Reccurent wheezing (statistics = -2.3278, p = 0.0199), and interstitial pneumonia vs. reccurent wheezing (Z statistics = -2.0414, p = 0.0412).

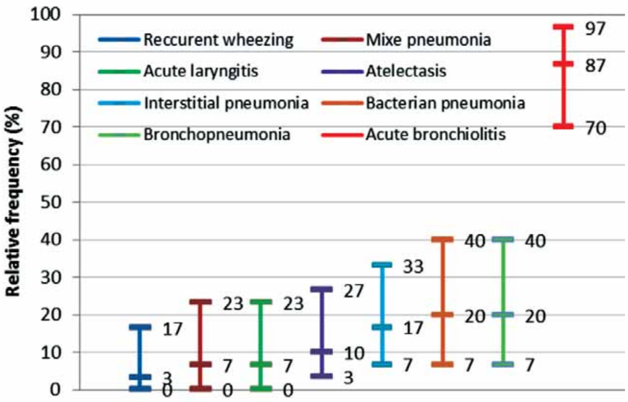

FIGURE 1. *Distribution of ARF on the sample; the mid line represents the percentage while the extreme values respresent the lower and upper bound of the 95% confidence interval*

A significantly higher number of subjects presented ARF of grade II or III compared to ARF grade I (Z statistics = -4.3818 (p < 0.0001), and -3.3541 (p = 0.0008), respectively, Fig. 2).

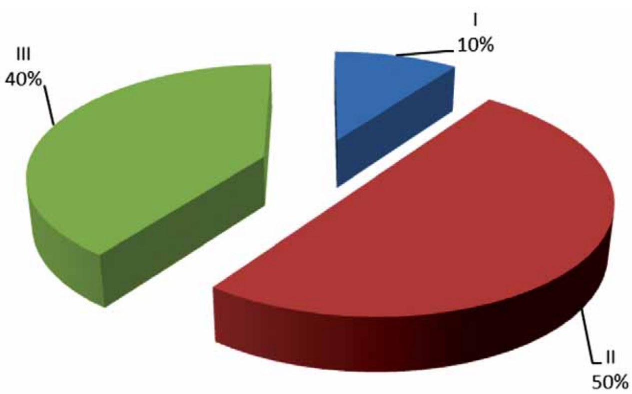

FIGURE 2. *Grade of ARF*

The clinical score of the investigated sample varied from 4 to 10 for the baseline (7.87±1.59) and 30 minutes (7.77±1.72) determination, and from 3 to 9 for the 60 minutes (6.50±1.83) determination. The evolution of the clinical score during investigation is presented in Figure 2. Significant differences were identified between the clinical scores evaluated at baseline, 30 minutes and 60 minutes after oxygen therapy (Friedman ANOVA: statistics = 57.0217, p < 0.001), but the differences were only significant when the clinical score at baseline was compared to the clinical score at 60 minutes, and when the clinical score at 30 minutes was compared to the clinical score at 60 minutes (Figure 3).

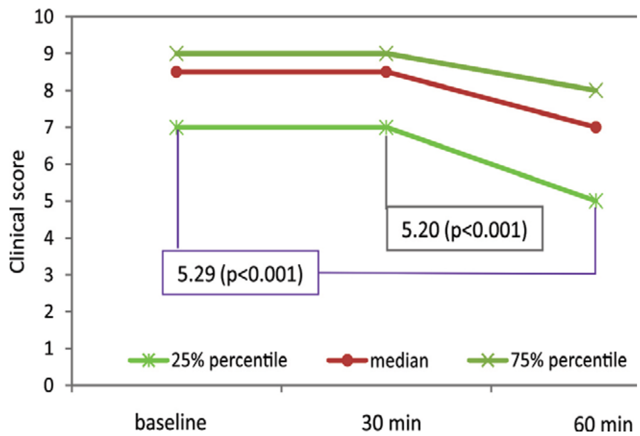

FIGURE 3. *Clinical score evolution by time*

Summary statistics of the SaO_2 measured throuth ASTRUP and pulse oximetry is presented in Table 1. Significant differences were identified when the values of SaO_2 (%) according to the time of determination were compared (Friedman ANOVA: statistics = 54.20, p < 0.001), as well as when the SpO_2 (%) were compared (Friedman ANOVA: statistics = 60.00, p < 0.001). The differences between all possible pairs were statistically significant (Z statistics associated to Sign test ≥ 4.930, p = 0.000001), sustaining the efficiency of the applied oxygen therapy. The evolution of SaO_2 measured by the used methods is presented in Fig. 4.

TABLE 2. *Average and standard deviation of measurements SaO_2, SpO_2, and pO_2*

Parameter	Baseline	30 minutes	60 minutes
SaO_2	83.22 ± 3.78	88.59 ± 2.76	92.88 ± 3.21
SpO_2	85.20 ± 3.02	89.53 ± 2.66	93.93 ± 2.83
pO_2	52.12 ± 13.57	61.23 ± 11.82	69.89 ± 11.44

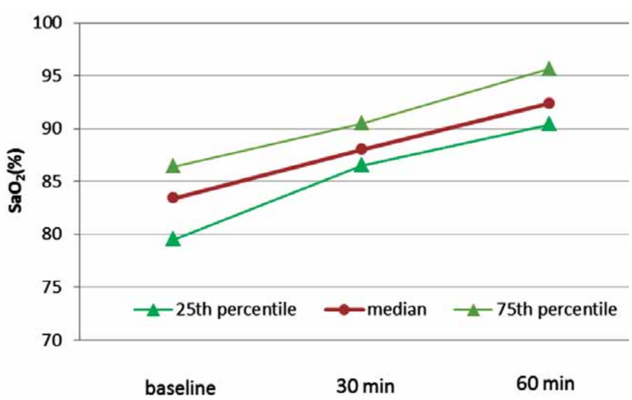

FIGURE 4. *The evolution of SaO_2*

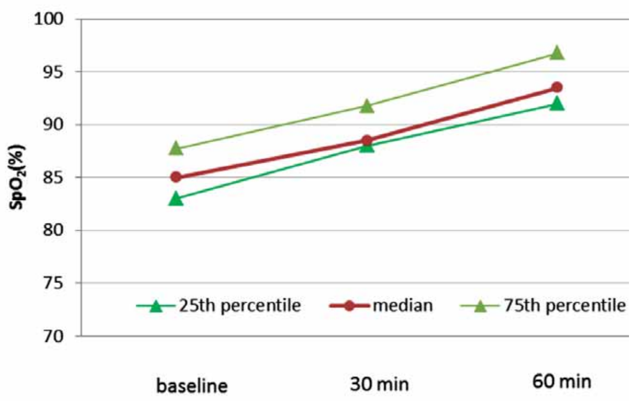

FIGURE 5. *A high statistically significant concordance between values of SaO_2(%) and of SpO_2(%) at all determinations.*

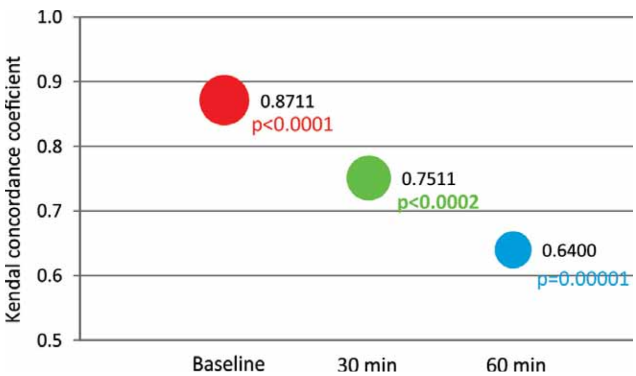

FIGURE 6. *Kendall's coefficient of concordance between SaO_2(%) and SpO_2(%)*

Summary statistics of the pO_2 measured throuth ASTRUP is presented in Table 1. Significant differences were identified when the values of partial pressure of O_2 according to the time of determination were compared, with the smallest value at baseline and highest value at 60 minutes after oxygen administration (Friedman ANOVA: statistics = 54.20, $p < 0.001$). The differences between all possible pairs were statistically significant (Z statististics associated to Sign test ≥ 4.929, p = 0.000001), sustaining the efficiency of the applied oxygen therapy. The evolution of pO_2 measured by the used methods is presented in Figure 7.

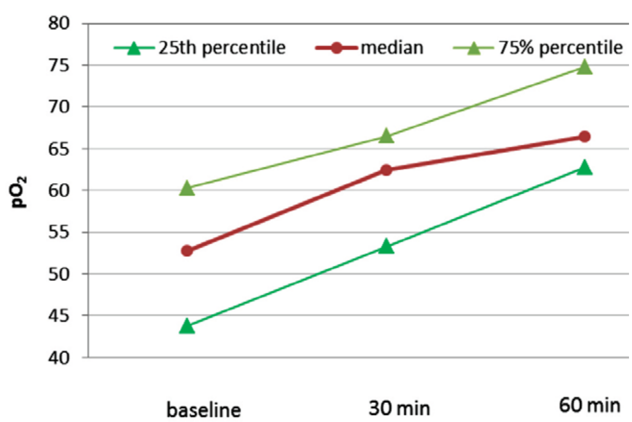

FIGURE 7. *The evolution of pO_2*

DISCUSSIONS

According to the grade of ARF, the patient group was classified as 10% mild form, 50% moderate form, 40% severe form. In the group of 30 patients suffering from pneumogenic ARF, the etiology was dominated by acute bronchiolitis, which was present in 26 cases, representing 86.66%. Compared to the baseline values, measured before the initiation of oxygen therapy, we recorded a statistically significant improvement in the clinical score both 30 minutes and 60 minutes after the initiation of oxygen therapy.

Other studies that used a clinical score to appraise patients with ARF have demonstrated the importance of such score for the appraising of the severity of ARF, and the monitoring of the patient's progress and response to therapy. (12,13). This study has demonstrated that both methods of measuring hemoglobin oxygen saturation (in capillary blood and by pulse oximetry) have recorded statistically significant increases in this variable after 30 minutes and 60 minutes, respectively, from the initiation of oxygen therapy by head box. Kendall's coefficient of concordance shows statistically significant concordance between the values of SaO_2 and SpO_2 at all three determinations.

Studies in the specialized literature mention the importance of initial appraisal and periodic reappraisal of SaO_2 in patients with pneumogenic ARF in arterialized capillary blood and by pulse oximetry (16,17). Some studies have demonstrated that pulse oximetry, which is a noninvasive method, can be used to determine SpO_2 for the periodic or continuous monitoring of patients with ARF, and can replace from time to time SaO_2 determination in arterialized capillary blood, which is an invasive method (18,19,20). This study has shown that partial pressure of oxygen recorded a statistically significant increasing trend both at the 30 minute and the 60 minute determination and the studies in the specialized literature also mention an increase in partial pressure of oxygen after oxygen therapy administration (21,22).

CONCLUSIONS

Oxygen therapy administered by head box ameliorates ARF appraised by clinical score. Oxygen therapy administered by head box to infants significantly increases the values of partial pressure of oxygen and hemoglobin oxygen saturation measured in capillary blood, as well as the values of hemoglobin oxygen saturation determined by pulse oximeter both after 30 minutes and 60 minutes. The increases in the three parameters are larger after 60 minutes. There is a statistically significant concordance between the values of hemoglobin oxygen saturation determined in capillary blood and by pulse oximetry at all determinations.

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