Intervention for ineffective airway clearance in asthmatic children: A controlled and randomized clinical trial

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Accepted for publication July 2012


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This study aimed to analyse the effectiveness of an intervention for the nursing diagnosis of ineffective airway clearance in asthmatic children. A blinded, randomized and controlled clinical trial was developed in a paediatric hospital located on northeast of Brazil with 42 asthmatic children aged ≤ 36 months. The children were randomly divided into two groups (intervention and control) by means of a simple drawing. The applied intervention included actions related to change of positioning and stimulation of cough. The main findings of this study show that before the intervention, no significant difference was observed in the health status of the children. After the intervention, the indicators of choking (16.83 vs. 26.17, \( P = 0.007 \)) and adventitious breath sounds (16.4 vs. 26.6, \( P = 0.005 \)) were higher, on average, in the intervention group. It was observed an improvement in obstructive symptoms in children who received the intervention proposed.

**Key words:** airway obstruction, asthma, child, nursing care, nursing diagnosis.
INTRODUCTION

Ineffective airway clearance (IAC) is a clinical situation in which there is an inability to clear secretions or obstructions from the respiratory tract to keep it permeable.\(^1\) This situation can lead to serious breathing difficulties and, if not reversed, increase the risk of imminent death. Thus, airway clearance is a problem of nursing responsibility that requires studies about the effectiveness of the interventions implemented. In addition, nursing interventions directed at this problem should be immediate and effective to relieve respiratory distress. In this article, it is assumed that a set of nursing activities improve the IAC of children with asthma.

Some diseases, such as asthma, are strongly related to reduction of the permeability of the airways and a previous study identified IAC in almost 70% of children hospitalized with asthma.\(^2\) It is known that airway obstruction might be related to mucociliary dysfunction and chronic, excessive secretion of mucus, which are pathophysiological characteristics present in asthma. This disorder is characterized by persistent inflammation, hypertrophy, hyperplasia and metaplasia of the submucosal glands, which contribute to airway obstruction, the formation of mucus plugs and bacterial colonization.\(^3\)

There is a strong relationship between IAC and the presence of secretions in the airways of children with asthma.\(^4\) The presence of secretions increases airway resistance to airflow, even if bronchoconstriction is reversed.\(^5\) Furthermore, other researchers have demonstrated that IAC is directly related to other nursing diagnoses, such as ineffective breathing patterns and impaired gas exchange, which confirms the need for immediate interventions.\(^6\)

Although airway obstruction is a prevalent medical condition among children with asthma, there are a few studies presenting the effectiveness of nursing interventions for this problem. One reason for this shortage is the short period of time available between the onset of a bronchial obstruction crisis and the beginning of the interventions commonly used.

Nursing researchers have highlighted the need to develop research on nursing interventions to provide better nursing care.\(^7\) Some authors have described the applicability of interventions of the Nursing Interventions Classification for IAC, and they have concluded from the links between nursing taxonomies that there is a need for studies and testing protocols for nursing interventions.\(^9\)

In short, it is known that a small number of studies relate to the evaluation of nursing interventions for IAC and asthma attacks in children, which together are responsible for a large number of hospitalizations and for high costs in the health-care sector. In the present study, we verified the effectiveness of a set of nursing actions directed to reverse IAC in asthmatic children.

METHODS

The study

A blinded, randomized and controlled clinical trial was performed to verify the effect of an intervention for asthmatic children in a paediatric hospital located in northeast of Brazil. Forty-two children were randomized into two groups (intervention and control). The control group was composed of children who received the standard medical treatment and typical nursing interventions usually implemented in the paediatric unit. The intervention group was composed of children who, in addition to standard medical treatment, received the intervention proposed in this study.

The inclusion criteria in the study were: asthma diagnosed by a physician, the presence of IAC based on the assessment and physical presence of defining characteristics and related factors described in the NANDA International taxonomy,\(^1\) age \(\leq 36\) months, and the presence of secretions identified by auscultation of adventitious breath sounds (rales or wheezing) in at least the top or basis of one lung. Children who had other diseases were excluded.

Children eligible for the study were identified from medical records. Subsequently, one author of the study evaluated each eligible child in order to identify the presence of IAC. This assessment was based on operational definitions for the defining characteristics and related factors described in the NANDA International taxonomy.\(^1\) The presence of nursing diagnosis was defined by consensus between two members of the study team. Each eligible child was allocated randomly in the experimental group or control group. An algorithm of random numbers was created with support from the R software version 2.9 (R Foundation for Statistical Computing, Vienna, Austria) and used for allocating the children in groups. The team member responsible by randomization did not participate in the interventions or the outcome evaluations.

Ethical considerations

Ethical approval was obtained from the institution’s Internal Review Board. The parents or guardians of all children enrolled provided written informed consent prior to data.
collection. Confidentiality was guaranteed regarding information and the child’s identity.

The intervention

In general, the adoption of a single nursing action is insufficient to reverse the IAC. Thus, this clinical condition requires multiple and immediate actions to improve the patients’ respiratory status. The literature describes many actions that can be implemented by nurses for this nursing diagnosis. However, it is important to identify a minimum set of actions that will improve the patient without spending excessive time or costs.

The use of tapping has been recommended in the literature by allowing the mobilization of secretions. However, this mobilization does not allow that the secretion is expelled efficiently without requiring the stimulus of cough. Finally, the position is a measure that promotes lung expansion and relief of symptoms of airway obstruction. The use of these actions separately is inefficient and can be ethically unacceptable. Thus, after reviewing the literature, these three actions implemented together (tapping, stimulation of coughing and positioning) were considered as essential for a possible reversal of IAC.

The intervention was built on a literature review that included textbooks and articles available in the LILACS, MEDLINE, CINAHL and PubMed databases. This review aimed to identify a minimum set of appropriate actions to reverse ineffective airway obstruction in children with asthma and the order in which each of these actions should be implemented. Thus, all children in the intervention group were subjected to three actions in a pre-established order as follows:

1. Placing the child in the prone position with the head at a lower level than the rest of the body, putting a bed sheet over the child’s skin and tapping with one hand only (in the hand dome, fingers clenched, palms cupped and with thumb adduction, creating a cushion of air between the hand and chest; the motion should be restricted to the joint and should avoid movement of the elbow and shoulder);

2. Stimulating the cough passively, putting the child in the supine position and performing a brief thumb pressure on the tracheal conduit in his or her thoracic outlet sternum (sternal notch); the move was to be performed preferentially in cases of inspiration or early expiration, and the nurse was to hold in the palm of the hand as much as possible the waistband of the child, which would greatly increase the upward effect of expulsion; and

3. Placing the child in the supine position with the headboard elevated 45 degrees and with hip semiflexion.

This intervention was applied to children by three authors of the study who were previously trained for the development of the intervention. Then another author evaluated the children without the knowledge of which group each child belonged to. For the control group, the nursing activities implemented were medication administration and nebulization, in addition to routine care, such as nutrition and bathing.

The baseline and follow-up measures

The baseline and subsequent measures to intervene were obtained from indicators of ‘respiratory status: airway patency’ from the Nursing Outcomes Classification. Operational definitions for these indicators were constructed in accordance with a previous study by Silva et al. The indicators used in this study were: respiratory rhythm, anxiety, choking and adventitious breath sounds.

In summary, the study variables were evaluated considering the following aspects:

- Respiratory rate: regularity of breathing movements in time intervals of 1 min;
- Anxiety: based on the presence of tachycardia, sudoresis, muscle tension, trembling and crying;
- Choking: Inability to emit sounds, dyspnoea, wheezing and cyanosis;
- Adventitious breath sounds: wheezing and rales distribution in the regions of auscultation;
- Dyspnoea: difficulty breathing characterized by extensive and rapid breaths;
- Diminished breath sounds: reduction of the noise intensity of inflation during the phases of inspiration and expiration;
- Orthopnoea: observation of the child’s need to remain sitting or standing to seek relief from respiratory distress;
- Ineffective cough: cough insufficient to expel sputum;
- Cyanosis: blue colouration of the skin, mucous membranes and extremities;
- Difficult vocalization: the difficulty presented by the child to verbalize words or typical sounds of the age;
- Restlessness: lack of mental and/or motor serenity of the child;
- Wide eyed: protrusion of the eyeball resulting effort to breathe;
Changes in respiratory rate: for children until 4 years, it was considered a frequency lower than 20 or greater than 30 breaths per minute. For children older than 4 years, it was considered a frequency lower than 14 or greater than 25 breaths per minute;

Excessive sputum: Parents’ perception of sputum expelled in quantities above normal for the child in the last 24 h.

**Data analyses**

Absolute frequencies and percentages for nominal data and measures of central tendency and dispersion for quantitative variables are presented. Statistical tests were applied to identify the homogeneity of the baseline characteristics of the children in both groups (intervention and control). The Kolmogorov–Smirnov test was applied to assess the normality of quantitative data, Levene’s test was applied to verify the homogeneity of variances and a t-test was used to compare means. When the data did not follow a normal distribution, non-parametric tests were used for the comparison of medians (rank means). The Mann–Whitney test was used to verify median differences between the experimental and control groups for each evaluated indicator. In this case, the groups were considered independent. The Wilcoxon signed-rank test was used to compare changes of the indicators within each group separately. For association analysis between two qualitative variables, a chi-squared test was applied to assess independence. When the data had expected frequencies less than five, Fisher’s exact test was used. Statistical significance was assumed at $P < 0.05$.

**RESULTS**

Most children were male (57.1%), with a mean age of 20.90 months ($\pm$ 10.382), mean weight of 11.3 kg ($\pm$ 2.739) and a median of 2 days of hospitalization. Comparing the groups, no significant difference was found for gender or time of hospitalization. The intervention group showed weight and age means significantly higher than the control group (Table 1).

The proportions of each defining characteristic of IAC were similar between the experimental and control groups at baseline (Table 2). All children presented related
Table 3 Mean rank of NOC indicators before and after the interventions in the study groups

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Control</th>
<th>Intervention</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory rhythm</td>
<td>20.33</td>
<td>20.68</td>
<td>0.909</td>
</tr>
<tr>
<td>Anxiety</td>
<td>6.00</td>
<td>4.29</td>
<td>0.450</td>
</tr>
<tr>
<td>Choking</td>
<td>20.45</td>
<td>22.55</td>
<td>0.362</td>
</tr>
<tr>
<td>Adventitious breath sounds</td>
<td>21.02</td>
<td>21.98</td>
<td>0.698</td>
</tr>
<tr>
<td>After intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory rhythm</td>
<td>19.10</td>
<td>21.90</td>
<td>0.253</td>
</tr>
<tr>
<td>Anxiety</td>
<td>5.50</td>
<td>4.86</td>
<td>0.593</td>
</tr>
<tr>
<td>Choking</td>
<td>16.83</td>
<td>26.17</td>
<td>0.007</td>
</tr>
<tr>
<td>Adventitious breath sounds</td>
<td>16.40</td>
<td>26.60</td>
<td>0.005</td>
</tr>
</tbody>
</table>

* Mann–Whitney test. NOC, Nursing Outcomes Classification.

Table 4 Intra-group mean ranks before and after the intervention

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean difference</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory rhythm</td>
<td>4.50</td>
<td>0.008</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.50</td>
<td>0.180</td>
</tr>
<tr>
<td>Choking</td>
<td>8.50</td>
<td>0.000</td>
</tr>
<tr>
<td>Adventitious breath sounds</td>
<td>9.50</td>
<td>0.000</td>
</tr>
<tr>
<td>Control group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory rhythm</td>
<td>2.50</td>
<td>0.059</td>
</tr>
<tr>
<td>Anxiety</td>
<td>0.00</td>
<td>1.000</td>
</tr>
<tr>
<td>Choking</td>
<td>3.00</td>
<td>0.025</td>
</tr>
<tr>
<td>Adventitious breath sounds</td>
<td>4.00</td>
<td>0.048</td>
</tr>
<tr>
<td>Intervention group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory rhythm</td>
<td>2.50</td>
<td>0.059</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.50</td>
<td>0.180</td>
</tr>
<tr>
<td>Choking</td>
<td>6.00</td>
<td>0.003</td>
</tr>
<tr>
<td>Adventitious breath sounds</td>
<td>8.50</td>
<td>0.000</td>
</tr>
</tbody>
</table>

* Wilcoxon test.

The defining characteristics of IAC most frequent in both groups were similar to those found in the Silveira et al. study and included adventitious breath sounds, ineffective cough and diminished breath sounds, which were statistically associated with the occurrence of IAC. The authors reported that diminished breath sounds and the presence of adventitious breath sounds increased by 6 and 48 times, respectively, the risks of IAC.

In this study, it was observed that at baseline, the health status of children in both groups was statistically similar (P > 0.05). The average reduction in the degree of impairment observed for the indicators of choking and adventitious breath sounds in the intervention group confirmed the findings by other authors, who described these clinical indicators as those that responded more directly to interventions to improve the airways’ permeability.

Airflow obstruction in asthma attacks is related both to the contraction of bronchial muscles and to hypersecretion. The use of inhaled beta-2 agonist medications has good results in relaxing bronchial muscles but almost negative effects on the removal of the excess mucus were produced. It is noteworthy that although this intervention did not include activities aimed at spasm of the airways or hyperplasia of the bronchial mucosa, most children in the study used drugs to improve these factors as part of the standards of the hospital in which the study was conducted.

On this topic, Lai and Rogers discussed the impact of mucus hypersecretion on airflow obstruction in asthmatic patients, demonstrating that the presence of a thin film of mucus could increase airway resistance to airflow up to 20 times during bronchoconstriction compared with an airway without the presence of mucus. Whereas the mucus in the airways of asthmatic patients is highly viscous and forms caps that are difficult to remove by coughing, the results of these authors support the improvement of
the respiratory status of children in the intervention group of this research obtained through bronchial hygiene measures.

Barnabé et al. highlighted that the use of hand techniques for bronchial hygiene, and not to induce bronchospasm in stable patients with asthma, improved lung function. The authors explained this improvement as the result of relaxation of the thoracic muscles and the largest mobilization of airway secretions. In their study, the authors found that the presence of respiratory symptoms decreased in between 43% and 64% of asthmatic patients after they received respiratory therapy.

Jones and Rowe, studying the techniques of bronchial hygiene in patients with bronchiectasis and chronic obstructive pulmonary disease, found that the hand techniques for hygiene improved bronchial airways, with increased excretion of mucus. This is a similar result to that found in the present study, in which the intervention group showed statistically significant differences for the indicators of choking and adventitious breath sounds when comparing the results before and after the implementation of interventions. Although the control group also had a significant difference, the values of their mean scores were lower than the intervention group. Similar findings were made by Bellido et al., who developed a physiotherapy treatment for children with asthma using similar measures of bronchial hygiene. The authors reported on the interventions implemented after a significant improvement of bronchial obstruction, with reductions in the quantity and viscosity of secretions and their bleaching.

Moreover, Didario et al., when evaluating the effectiveness of chest physiotherapy in asthmatic children under observation in the emergency department, found no differences over time in the health status of children from two groups and compared the effect of a physiotherapy intervention in children with severe asthma attacks. The final health status of children improved in all hospitalized patients, regardless of physical therapy manoeuvres. For the authors, these findings suggested that for children in the emergency department, the expense, time and effort involved in dealing with respiratory therapy cannot be justified.

It is noteworthy that although that study worked with children with asthma, they were treated in different clinical conditions than the children enrolled in the present study. Moreover, Schans described in his work that cleaning of the airways increased the transport of mucus through the bronchi, thus generating a smaller decline in lung function, decreasing the rate of pulmonary infection and hospitalization, and improving quality of life.

Despite the care with which all the methodological processes of this study were carried out, including the selection and evaluation of the children recruited for the study, some conditions might limit the generalization of these findings. One must consider the fact that children in the intervention group showed higher values for age and weight. However, the group, as a whole, comprised children under the age of 36 months who were therefore considered more susceptible to asthma attacks. The weight difference can be explained by its direct relationship with the children’s ages.

In this study, the effect of the intervention was evaluated at a single moment. However, this limitation was due to the fact that the obstruction of secretion is a phenomenon that is quickly reversed and is strongly connected to working together with other professionals. The implementation of the intervention on subsequent days might possibly be influenced by residual effects of the joint working team, which would make it difficult to identify the actual contribution of the intervention itself.

Moreover, the limited literature addressing nursing intervention studies for the diagnosis of IAC makes it difficult to discuss the data and compare the findings of similar studies. However, this lack demonstrates the need for such studies to support the construction of clinical evidence for nursing in accordance with suggestions presented by other researchers.

In conclusion, this study found an improvement in obstructive symptoms in children who received the intervention proposed, with significant changes in the indicators of choking and adventitious breath sounds. This research recommends studies to implement the proposed intervention throughout the period of hospitalization to determine the possible relationship between the intervention and a reduction in the length of hospital stay.

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