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Original Research Article

Outcomes of parent education programme in regular respiratory physiotherapy in prolonged mechanical ventilated child via tracheostomy after home- discharge

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The purpose of this research is to investigate the results of parental education and the systematic application of respiratory physiotherapy in the case of a child with tracheostomy and prolonged mechanical ventilation at home. Physiotherapy intervention included parent training in the application of physiotherapy techniques and the application of systematic respiratory physiotherapy for a period of 5 months. The child was evaluated before and after the intervention by completing a questionnaire. The measurements made are pulse oximetry before and after each physiotherapy session, arterial blood gases and nocturnal oximetry at the end of each month. An improvement in oxygen saturation (SaO_2) was observed, with statistically significant differences between pre-post physiotherapy measurements ($p<0.05$). Throughout the intervention, blood PO_2, PCO_2, HCO_3^- was improved, but there was no statistically significant difference between the measurements ($p>0.05$). Also, statistically significant differences ($p<0.05$) occurred in nighttime oximetry throughout the intervention, which augmented the interruption of oxygen delivery during sleep. Completing the assessment questionnaire showed improvement in the family's psychological profile and quality of life. The contribution of respiratory physiotherapy to children with tracheostomy and prolonged mechanical ventilation is considered to be very important both in the Intensive Care Unit of Children and after hospital discharge. Further research is needed to clarify its effects on improving pulmonary function, preventing respiratory infections, reducing hospital admission, releasing children from the ventilator and / or tracheostomy, and improving their quality of life.

Key words: Pediatric tracheostomy, mechanical ventilation, tracheostomy parental education, chest physiotherapy.

INTRODUCTION

In recent years, modern developments in medicine at Pediatric Intensive Care Unit and the development of modern equipment have resulted in an increase in the survival rate of children with chronic respiratory insufficiency and an increase in the number of children with tracheostomy requiring prolonged mechanical ventilation (Pérez-Ruiz et al., 2012) (Serra et al., 2012) (Ertugrul et al., 2016).

The most common indications of tracheostomy in children are:

1. Upper airway obstruction (craniofacial malformations, craniofacial tumors and laryngeal tumors, obstructive sleep apnea).
2. Laryngotracheal abnormalities (bilateral vocal chord paralysis, laryngeal obstruction, severe tracheomalacia, sublingual stenosis due to intubation in preterm infants).
3. Cardiopulmonary causes.

4. Neuromuscular disorders.
5. Congenital abnormalities.
6. Inability to protect the airway due to reduced level of consciousness.
7. Inability to extubate and need for prolonged mechanical ventilation.

(Barbato et al., 2012) (Funamura et al., 2014).

Until now, children with tracheostomy and mechanical ventilation have been hospitalized for a long time in the hospital away from their familiar environment with unpleasant effects on their psychology and development, and high treatment costs (Edwards et al., 2004) (Edwards et al., 2004, (Hsia et al., 2012). Progress in ventilator technology and respiratory rehabilitation programs have increased the chances of these children getting discharged from the hospital and return home safely (Leurer et al., 2006). Research has shown that psychosocial development and quality of life of children and their families is better at home (Fields et al., 1991) (Edwards et al., 2004); (Hsia et al., 2012).

Respiratory physiotherapy plays a major role in the therapeutic approach of these patients. The goals of respiratory physiotherapy are: cleaning secretions from the bronchi and the upper airways, improving pulmonary ventilation, improving oxygenation, reducing work of breathing, enhancing effective cough, treating and preventing atelectasis, minimizing the effects of prolonged bedtime, prevention of respiratory infections, reduction of hospital admissions, disconnection from mechanical ventilation and avoidance of re-intubation (McCord et al., 2013).

Parental training, continuous monitoring and good collaboration with the medical team is necessary to achieve a safe and successful exit from the hospital (Cross et al., 1998) (Leurer et al., 2006) (Zia et al., 2010). The complexity of the clinical condition of these children requires the collaboration of all members of the interdisciplinary rehabilitation team, an integral part of which is also the physiotherapist.

CASE STUDY

This is a 6-year-old girl who was generally a healthy child before the current disease, fully vaccinated for his age, without allergies and without long-term medication.

The girl first got sick before 1,5 year presenting symptoms of upper respiratory infection and fever. After a week of intermittent fever and gradually worsening general condition, the child was admitted to hospital with depressed conscious level and possible partial seizures during the night (stereotypic movements of the left upper limb, tooth tremors). A few hours after being admitted to the hospital, she presented signs of respiratory failure, she was intubated and transferred to the Pediatric Intensive Care Unit.

The child remained in a comatose state for a week. When gradually sedative drugs stopped, the child regained consciousness very quickly, she showed adequate reaction and recognized family members right away. Unfortunately, she showed a flaccid quadriplegia with the absence of deep tendon reflexes. She presented normal cranial nerves and cognitive function.

Shortly after her admission to Pediatric Intensive Care Unit (PICU), a lumbar puncture was performed, in which herpes simplex virus I (positive PCR for HSV I) was detected and a diagnosis of herpes encephalitis was established. Throughout the patient's hospitalization, three magnetic resonance imaging (MRI) of the brain and spinal cord were performed, which revealed damage to the white matter of both hemispheres, as well as extensive spinal cord damage along its length and cervical nerve roots.

One month later, the patient underwent a tracheostomy, as she never exhibited adequate respiratory effort and until now she remains in complete mechanical ventilation support. The child remained in the Pediatric Intensive Care Unit for 5 months in complete ventilator dependence and with flaccid quadriplegia (complete high-level sensorimotor transverse spinal cord syndrome). The mechanical ventilation model used was Assisted Pressure Control Ventilation (APCV). She presented colonization of bronchial secretion with Klebsiella pneumonia and Methicillin-sensitive Staphylococcus aureus (MSSA).

The child demonstrated facial muscles, she was able to vocalize and swallow, while the upper brain functions were intact. She was fed orally. She presented a neurogenic bladder dysfunction, compensated by intermittent bladder catheterizations and neurogenic bowel dysfunction (colonization with Klebsiella pneumonia) and central body temperature disorder.

Five months later, the child was transferred to a rehabilitation center abroad. She attended rehabilitation program for 5 months. Unfortunately, experts at this center felt that according to the findings, improvements can no longer be expected with respect to child's motor abilities and her ability to breath independently. That's why the family decided to return to Greece, where the children was taking care of themselves at home.

Measurements

The measurements made are:

1. Pulse oximetry: recording of oxygen saturation (SaO_2) before and 30min after physiotherapeutic intervention, using the Nonin 2500 palmsat pulse oximetry.
2. Arterial blood gases: analysis was performed at the end of each month and included parameters of partial pressure of O_2 in arterial blood (PO_2), partial pressure of partial pressure of CO_2 in arterial blood (PCO_2) and bicarbonates (HCO_3^-).
3. Night oximetry: At the end of each month, oxygen saturation (SaO_2) was determined overnight using a pulse oximeter. The range of sleep time rates in which oxygen saturation (SaO_2) was from 85-90%, 90-95% and 95-100% was recorded.

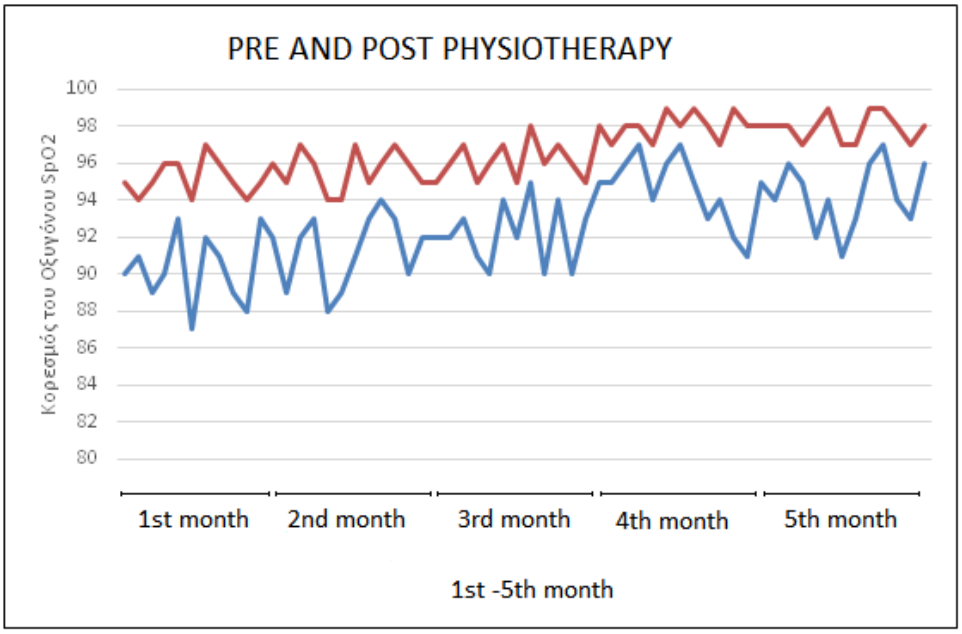

Figure 1: Oxygen saturation of SaO_2 pre and post physiotherapy throughout the intervention.

Physiotherapy intervention

The respiratory physiotherapy program followed included the following techniques:

- Modified drainage positions.
- Percussion.
- Pressure - Vibration.
- Exercise of the diaphragm.
- Breathing exercises.
- Change position every 2 hours.
- Cough.
- Massage in the abdomen.

Before the start and immediately after the end of the physiotherapy intervention, the child's assessment was made on the basis of the evaluation questionnaire created by ourselves. Physiotherapeutic intervention included parent training in the application of physiotherapy techniques in the first 2 weeks of intervention on a daily basis. The physiotherapy program was then applied twice a day by the parents daily and 3 times a week by the physiotherapist, where the control of the way of application by the parents was carried out as well as the development of the child's course. The intervention lasted for 5 months and the duration of each session was 60 minutes. Physiotherapy was combined with inhaled treatment.

RESULTS

The analysis of the results showed an improvement in oxygen saturation SaO_2, with statistically significant differences (1st month sig.0.00 <0.05, 2nd month sig.0.00 <0.05, 3rd month sig.0.00 < 0.05, 4th month sig.0.002<0.05, 5th month sig.0,002 <0,05) between the pre- and post-physiotherapy measurements during all months of intervention (Figure 1). Throughout the intervention, blood PO_2, PCO_2, HCO_3^- was improved, but there was no statistically significant difference between the measurements (sig = 0.153> 0.05) (Figures 2,3,4). Also, statistically significant differences (sig. = 0.048 <0.05) in nocturnal oximetry occurred throughout the intervention. At the beginning of the intervention, the child had 90% - 95% oxygen saturation SaO_2 during 90% of sleep and 85% - 90% oxygen saturation of SaO_2 during 10% of sleep. After 5 months of systematically applying respiratory physiotherapy, oxygen saturation SaO_2 was 95-100% during 72% of sleep and oxygen saturation SaO_2 was 90-95% during 28% of sleep, which augmented the interruption of oxygen delivery during sleep (Figure 5).

The motion of the diaphragm is thought to have improved as the child presented the reflex of sneezing and hiccups. Also, improvement in mobilizing secretion with cough was observed, which was effective to move mucus from central bronchi near to tracheostomy. At the end of intervention, the number of tracheobronchial suctions decreased overall over the day and was almost eliminated overnight. Also, improvement in bowel motility was observed and the abdomen swelling, primarily caused by aerophagia resulting from leakage air- ventilation, was treated effectively with abdomen massage.

After ventilator weaning tests that occurred in the hospital, during child's formal re-inspection visit, the doctor claimed that she presents automatic breathing and she can disconnected from the ventilator for 5 minutes per day.

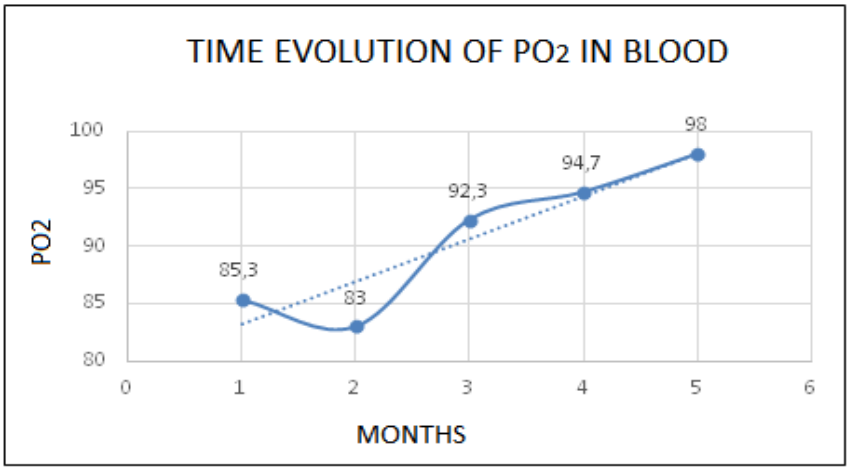

Figure 2: Progression of PO_2 in the blood during the 5 months, as well as the tension formed by dashed lines.

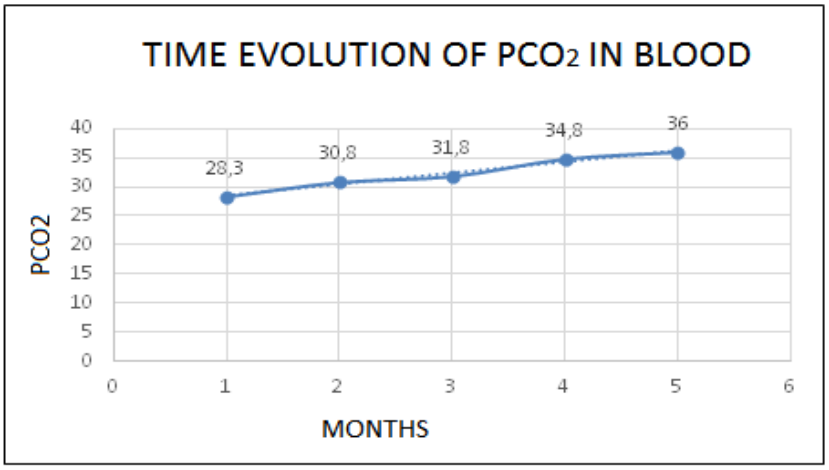

Figure 3: Progression of PCO_2 in the blood during the 5 months, as well as the tension formed by dashed lines.

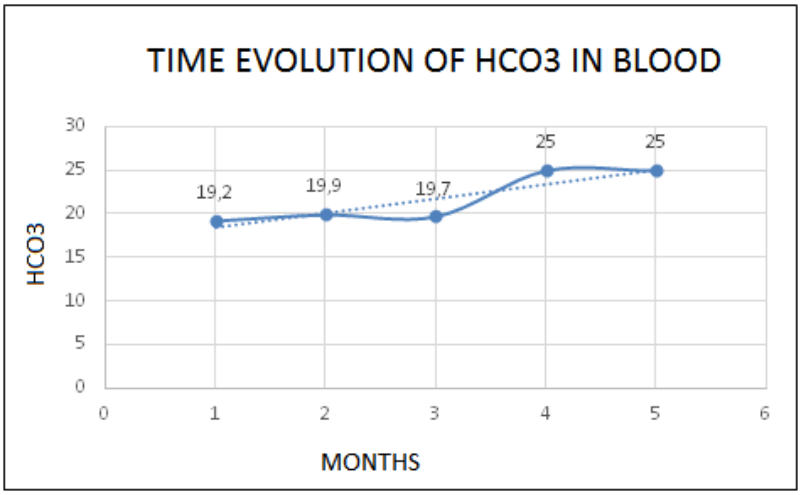

Figure 4: Progression of HCO_3^- in the blood during the 5 months, as well as the tension formed by dashed lines.

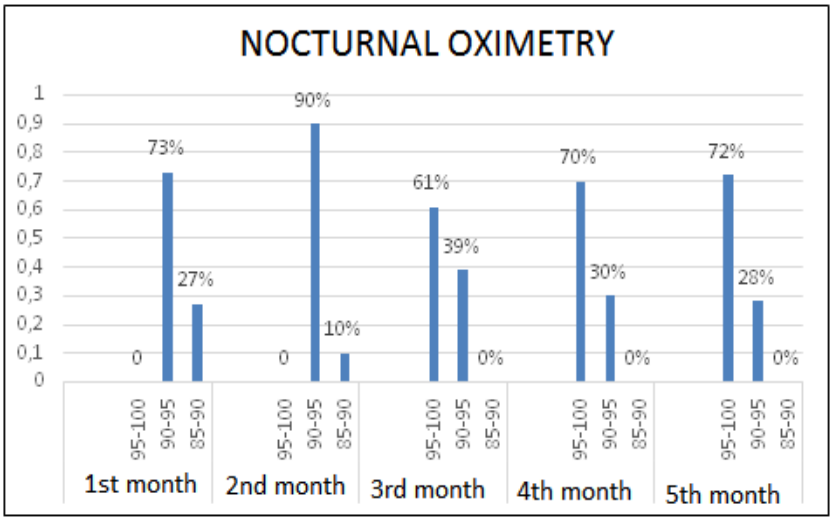

Figure 5: Graphic depiction of the results of nocturnal oximetry for each month separately and in aggregate

During physical therapy there was an improvement in the child's mobility. He presented an antibarian head movement from a slightly extended position to the middle position; head turning, and no longer required lateral support of the head. Activation of sternocleidomastoid, scalp and neck muscles and slight shoulder lifting was observed.

Completing the assessment questionnaire has shown an improvement in the psychological profile of the family and their quality of life. The parents felt very ready to take care of their child safely, without being difficult, even though her care required many hours a day. Sometimes, however, they still felt anxious and concerned about both her safety and her health. They participated daily in activities at home, such as reading, playing, gymnastics, cooking, and 1-2 times a month had established activities outside the home, such as outdoor walks, visits to the village, shopping, visits to friendly homes.

DISCUSSION

The results of the present study show a statistically significant difference (sig = 0.00 <0.05) in oxygen saturation (SaO_2) before and after the application of respiratory physiotherapy, as recorded in each session individually. This improvement is thought to have resulted as a result of better mobilization and elimination of secretions from the airways. This has been enhanced by the application of modified drainage positions, percussion, vibration-pressure, frequent change of positions and active participation of the child in respiratory exercises in the form of play.

There are researches in the literature supporting the use of modified drainage positions and the frequent change of position as the best means of draining the secretions. According to Oberwaldner 2000 and McIlwaine 2006, drainage positions in a Trendelenburg position are of no particular value in pediatric patients to enhance the mobilization of secretions, but they consider that frequent body position changes and the choice to place the patient in positions improves pulmonary ventilation in specific areas of the lungs, not only recruits the gravitational forces but also affects better ventilation, resulting in better pulmonary parenchyma dilatation and airway (Oberwaldner, 2000) (McIlwaine, 2006). Percussion is thought to cause changes in airway pressure, which stimulate the mobilization of the secretions by stimulation of cilia, fluid and gas interaction, and release of pulmonary chemical mediators that improve the transport speed of cilia (Lewis et al., 1992). The effects of pressure and vibration in the chest wall on the mobilization of secretions are also very important. A series of various physiological mechanisms have been proposed, including increasing the maximal expiratory flow and increasing expiratory air flow, which cause better mobility of the secretions from peripheral to central airways, from where they can be removed either by tracheobronchial suction or with coughing (McIlwaine, 2006) (Gregson et al., 2007) (Gregson et al., 2012). It is thought that the maximum expiratory flow increases by 80% from the initial values and the expiratory air flow by 30%, changes that are able to promote the mobilization of secretions even in low airflows (Gregson et al., 2012).

Almeida et al. (2005) observed that the application of chest wall pressures resulted in improved SaO_2 and partial pressure of PO_2 oxygen. Patients with invasive mechanical ventilation, who have acute obstruction, have viscous secretions and their mobilization by the chest wall pressure technique improves gas exchange (Almeida et al., 2005). This is confirmed in our own research with the significant increase in PO_2 partial pressure at the end of physiotherapy intervention (from PO_2 = 85.3 mmHg at 1 month gradual

increase in PO_2 = 98 mmHg at 5 months).

Also, an improvement in the partial pressure of carbon dioxide PCO_2 was observed, which was, as a counterbalance to bicarbonates, below the normal limits. The reduction of fluid and electrolyte loss (due to reduction of diarrheal stools), improved oral fluid intake and inhaled therapy combined with physiotherapy resulted in the loosing of viscous secretions, which by the application of systemic respiratory physiotherapy was mobilized and removed from the airways. This has led to clear airways from secretions and to maintaining the partial pressure of carbon dioxide PCO_2 within normal limits.

Promoting airway clearance of secretions, improving ventilation and improving oxygenation contributed to changes in nocturnal oximetry. At the beginning of the intervention, the child had 90-95% oxygen saturation SaO_2 in 90% of sleep and oxygen saturation SaO_2 85% to 90% during 10% of sleep, which supported the use of oxygen during sleep. After 5 months of regular respiratory physiotherapy, oxygen saturation SaO_2 was 95-100% in 72% of sleep and oxygen saturation SaO_2 was 90-95% in 28% of sleep. Because this percentage include intervals that tracheobronchial suction was done causing decrease of oxygen saturation SaO_2, it was considered by the treating physician that it can stop the administration of oxygen during the night.

The abdominal massage resulted in enhanced peristaltic bowel movements and provided significant relief in the bowel discharge, resulting in reduced laxative use and contributed to the treatment of abdominal swelling. Powell et al. (2010) also support the effect of bowel massage on bowel evacuation (Powell et al., 2010). The reduction in diarrheal stools has contributed to the increase in blood bicarbonate.

Although respiratory physiotherapy is considered to be an integral part of the treatment of children with tracheostomy and prolonged mechanical ventilation and is included in parental education programs, the review of the literature did not reveal many studies to investigate the effects of various respiratory physiotherapy techniques when children are discharged from the hospital and return home. Since different techniques are applied at the same time, it is difficult to determine the efficacy of each technique separately (McCord et al., 2013), which is a disadvantage in the present study.

Conclusion

The contribution of respiratory physiotherapy to children with tracheostomy and prolonged mechanical ventilation is considered to be very important both within the Pediatric Intensive Care Unit and after discharging hospital as it promotes better clearance of secretions from the bronchi and the upper airways, improves pulmonary ventilation and better oxygenation.

Further research is needed to clarify its effects on improving pulmonary function, preventing respiratory infections, reducing hospital admissions, reducing treatment costs, weaning from the ventilator and / or tracheostomy, and improving children's and family's quality of life.

RECOMMENDATIONS

Training parents with children with tracheostomy and mechanical ventilation, continuous monitoring and good cooperation of the interdisciplinary team are considered necessary optimizing the management of these children. It is recommended to integrate education of the application of respiratory physiotherapy to parents' training programs. It is recommended that this training should start very early, during the child's hospitalization, in order to achieve a safe and successful exit from the hospital and stay of the child at home.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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