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I Brazilian guidelines for respiratory physiotherapy in pediatric and neonatal intensive care units

I Recomendação brasileira de fisioterapia respiratória em unidade de terapia intensiva pediátrica e neonatal

These guidelines were drafted by the Department of Physiotherapy of the Associação de Medicina Intensiva Brasileira - AMIB - Brazil.

ABSTRACT

Developing guidelines for the role of the physiotherapist in neonatal and pediatric intensive care units is essential because these professionals are responsible for the rehabilitation of critically ill patients. Rehabilitation includes the evaluation and prevention of functional kinetic alterations, application of treatment interventions (respiratory and/or motor physiotherapy), control and application of medical gases, care of mechanical ventilation, weaning and extubation, tracheal gas insufflation, inflation/deflation of the endotracheal cuff protocol, and surfactant application, aiming to allow patients to have a full

recovery and return to their functional activities.

In this article, we present guidelines that are intended to guide the physiotherapist in some of the prevention/treatment interventions in respiratory therapy (airway clearance, lung expansion, position in bed, airway suction, drug inhalation, and cough assist), which help in the rehabilitation process of newborns and children in intensive care units during mechanical ventilation and up to 12 hours following extubation.

Keywords: Rehabilitation; Respiratory therapy; Physical therapy modalities; Intensive care, neonatal; Respiration, artificial; Child

INTRODUCTION

The role of physiotherapists with expertise in pediatric and neonatal intensive care is relatively new in Brazil, as the dissemination of courses and training in these areas primarily occurred from 2000 onwards. Currently, there are several courses nationwide that prepare physiotherapists to work with patients or perform research in these areas. In February 2010, the Brazilian Health Surveillance Agency (Agência Nacional de Vigilância Sanitária - ANVISA) published, in its official gazette,⁽¹⁾ the mandatory neonatology and pediatric expertise required for physiotherapists to work in these respective hospital areas. This improvement in the training of physiotherapists contributed to patient safety in pediatric and neonatal intensive care units (ICUs).

Physiotherapists working in these areas are responsible for kinetic functional assessment and prevention (for all or any human body system, as needed) and for treatment interventions (respiratory and/or motor physiotherapy). They also work with a multidisciplinary team in the control and application of medicinal gases, invasive and noninvasive (INV) mechanical pulmonary ventilation (MPV), protocols for weaning and extubation of MPV, tracheal insufflation of gas, protocol of insufflation/exsufflation of the endotracheal cuff, and surfactant application, among others.

Therefore, establishing guidelines for physiotherapists is very important. With

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this goal, members of the Department of Physiotherapy of the Brazilian Intensive Medicine Association drafted the I Brazilian Guidelines for Respiratory Physiotherapy in Pediatric and Neonatal ICU for the treatment of newborns (NBs), infants, children, and teenagers during MPV and in the period up to 12 hours after extubation. These guidelines cover airway clearance, lung re-expansion, bed positioning, airway aspiration, inhalation therapy, and assisted coughing.

METHODS

Six physiotherapists who are experts in neonatology and/or pediatric physiotherapy participated in drafting these guidelines; five of them conducted a literature review of articles published in the period from 2000 to 2012 using the PubMed, Embase, and PeDro databases with the keywords

“physiotherapy” and “chest physiotherapy,” which were cross-referenced with the keywords “mechanical ventilation,” “respiratory care,” “pediatric critical care,” “newborn,” “infant,” “airway clearance,” “mucus clearance techniques,” “mucociliary clearance,” “respiratory therapy,” “aerosol therapy,” and “cough assist.” Next, they used the PICO research scientific method, and the keywords mentioned above were cross-referenced with words from PICO (p = patients, i = intervention, c = control, o = outcome). The database queries were performed again by a librarian with over 15 years of experience in scientific research in the health area. To answer each question, her recommendation and the rationale were presented to justify the conduct recommended/suggested.

The five physiotherapists then classified the information based on grade of recommendation (A, B, C, or D) through the Oxford Centre method (Table 1).⁽²⁾ The sixth physiotherapist

Table 1 – Level of scientific evidence by study type

| Grade of recommendation | Evidence level | Treatment/prevention-etiology | Prognostic | Diagnosis | Differential diagnosis / symptoms prevalence |
|-------------------------|----------------|--|---|--|--|
| A | 1A | Systematic review (with homogeneity) of controlled and randomized clinic trials | Systematic review (with homogeneity) of cohort from the onset of the disease Prognostic criteria validated in diverse populations | Systematic review (with homogeneity) of level 1 diagnostic studies Diagnostic criteria of level 1B studies, in different clinic centers | Systematic review (with homogeneity) of cohort study (contemporary or prospective) |
| | 1B | Controlled and randomized clinic trials with narrow confidence intervals | Cohort, from the onset of the disease, with loss < 20% Prognostic criteria validated in a single population | Cohort validated, with good benchmark Prognostic criteria tested in one clinic center | Cohort study (contemporary or prospective) with a few losses |
| | 1C | Therapeutic results of “all or nothing” cases | Series of “all or nothing” cases | Sensibility and specificity close to 100% | Series of “all or nothing” cases |
| B | 2A | Systematic review (with homogeneity) of cohort studies | Systematic review (with homogeneity) of historical cohort (retrospective) or follow-up of untreated cases of the control group or of randomized clinic trial | Systematic review (with homogeneity) of diagnostic studies of level > 2 | Systematic review (with homogeneity) of studies on differential diagnosis of level ≥ 2b |
| | 2B | Cohort study (including randomized clinic trial of lower quality) | Study of historical cohort Follow-up of untreated patients of the control group and randomized clinic trial Prognostic criteria derived or validated only in fragmented samples | Exploratory cohort with good benchmark Prognostic criteria derived or validated in fragmented samples or database | Study of historical cohort (retrospective cohort) or with follow-up of impaired cases (great number of losses) |
| | 2C | Observation of therapeutic results (outcomes research) Ecological study | Observation of clinical evolutions (outcomes research) | | Ecological study |
| | 3A | Systematic review (with homogeneity) of case-control studies | | Systematic review (with homogeneity) of diagnostic studies of level ≥ 3B | Systematic review (with homogeneity) of studies of level ≥ 3B |
| | 3B | Case-control study | | Non-consecutive selection of cases or benchmark applied with little consistency | Cohort with non-consecutive selection of cases or very limited study population |
| C | 4 | Case reports (including cohort or control-case of lower quality) | Series of cases (and prognostic cohort of lower quality) | Control-case study or poor or non-independent benchmark | Series of studies or superseded benchmark |
| D | 5 | Opinion devoid of critical appraisal or based on basic subject (physiological study or study with animals) | | | |

Translated and modified from: Oxford Centre for Evidence-based Medicine. Levels of evidence and grades of guidelines. Available at: <http://www.cebm.net/index.aspx?o=1025>.⁽²⁾

reviewed the included and excluded articles and the grades of recommendation and edited the final document.

Inclusion criteria for articles were clinical trials that were retrospective, prospective, controlled, or non-controlled randomized performed with NBs, infants, children, and/or teenagers in ICUs during MPV or within 12 hours following extubation. We included articles that addressed at least one of the six central themes of these guidelines: airway clearance, lung re-expansion, bed positioning, airway aspiration, inhalation therapy, and assisted coughing.

The following were excluded for the drafting of guidelines: editorials, simple literature reviews, systematic reviews, meta-analyses, experimental studies with animals, and case reports. Literature reviews and some articles excluded from the guidelines were used in the introduction, in the drafting of the rationale.

GUIDELINES FOR AIRWAY CLEARANCE TECHNIQUES

Based on the literature review, the following factors were included in the guidelines for airway clearance techniques: 1) assessment, 2) expiratory flow increase (EFI), 3) manual hyperinflation (MH), and 4) chest percussion, as well as combinations of these four categories of respiratory physiotherapy techniques.

1. What should be assessed in NBs and children before, during, and after the airway clearance techniques?

For the safety of the patients and to ensure the effectiveness of these techniques, it is recommended to assess at least three of the following parameters before, during, and after their application: demographic characteristics (A),⁽³⁻⁵⁾ vital signs (heart rate, respiratory rate, and pulse oximetry - SpO₂) (A),^(3,4) noninvasive systemic blood pressure and arterial blood gas (A),⁽⁶⁾ alveolar pressure and its derived indices (D),⁽⁷⁾ dynamic compliance and airway resistance (B),⁽⁸⁾ inspiratory and expiratory tidal volume (C),^(9,10) forced expiratory volume (B),⁽⁸⁾ peak expiratory flow (PEF) and its ratio to peak inspiratory flow (PIF) (B),⁽¹⁰⁾ and maximum inspiratory pressure and MPV parameters (B).^(7,8,10)

Rationale

Respiratory physiotherapy techniques that are intended to dislodge and/or remove secretions from airways are called "airway clearance techniques." They can be advised or applied by physiotherapists in the neonatal and pediatric age groups,⁽⁷⁾ in clinical situations with increased

secretion in the airways,^(8,9) and for the prevention of complications related to MPV.⁽⁷⁾

Assessment of the patient allows identifying, relating, and prioritizing the problems, thereby assisting in the diagnosis and enhancing the benefits of interventions, especially considering that in most cases, airway clearance techniques are indicated in clinical situations with obstruction of airways caused by secretions and acute respiratory failure.⁽⁷⁾

2. In which situations and for what diseases can the EFI technique be applied?

EFI is recommended to be applied slowly to NBs and slowly or rapidly to infants with a diagnosis of severe acute bronchiolitis; this intervention is suggested to be performed least once a day (C).⁽⁹⁾

Rationale

During MPV, NBs and infants (aged from 26 to 41 weeks) with a diagnosis of severe acute bronchiolitis who developed the illness around the ninth week of life had increased SpO₂ and tidal volume when EFI was applied 5 to 10 minutes once a day.⁽⁷⁾

3. Do the MH technique with a self-inflating bag and its combination with other techniques favor the mobilization and displacement of airway secretions?

MH is recommended, with or without vibrocompression, for the mobilization and removal of airway secretions in pediatrics and neonatology (A).⁽⁶⁾

Rationale

MH is one of the techniques used routinely in ICUs. The slow insufflation of the self-inflating balloon and the inspiratory plateau recruit collapsed lung areas, while the quick release of the balloon promotes a rapid expiration, thereby increasing the expiratory flow rate and helping to mobilize secretions.^(11,12)

The mobilization of lower airway secretions is determined by the speed of the airflow in the airways. During the MH technique, the PEF must be greater than the PIF to displace the secretions to proximal airways, and the suitable ratio for this to occur is PIF/PEF \leq 0.9.⁽¹⁰⁾

An increase in inspired volume and PIP increases lung elastic recoil, which favors the mobilization of secretions throughout the respiratory system in infants and children (age range 0.02 to 13.7 years) submitted to MH combined with manual chest vibration and postural drainage.⁽¹²⁾

MH combined with vibrocompression during MPV of NBs and children (between 0 to 16 years) with a diagnosis of pulmonary consolidation or atelectasis increases the PEF, thereby increasing the volume of expired air and optimizing the clearance of lower airways.⁽⁶⁾

During MH, it is possible to affect the PIP and the tidal volume (e.g., by the use of one hand or both to compress the balloon, or by the use of a positive end-expiratory pressure (PEEP) valve), which influences the pressures and volumes offered to the patient and makes it necessary to use a pressure gauge while applying the technique to ensure safety and avoid barotrauma and/or volutrauma.⁽¹³⁾

The use of a pressure gauge to monitor the peak inspiratory pressure (PIP) during MH is suggested (it should not exceed 20 cmH₂O and 30 cmH₂O in NBs and children, respectively).

4. Which techniques are not recommended for airway clearance?

Thoracic percussion applied in NBs immediately after extubation is not recommended (A).⁽⁴⁾

We do not recommend airway desobstruction techniques such as postural drainage and/or chest vibration associated or not with MH with aspiration in cystic fibrosis children undergone endotracheal intubation in the perioperative period (B).⁽⁸⁾

Rationale

Thoracic percussion can increase intrathoracic pressure and hypoxemia. The latter effect is negligible when the technique is used for less than 30 seconds.⁽¹⁴⁾ Thoracic percussion performed routinely with a duration of one to two minutes in NBs (28 to 37 weeks gestational age) immediately after extubation may collapse small airways.⁽⁴⁾

A randomized study including 18 patients with cystic fibrosis (age varying from 3 to 15 years) undergoing anesthesia in the preoperative period compared desobstruction techniques (postural drainage and/or chest vibration, associated or not with MG and airway aspiration) with aspiration only and showed an increase in airway resistance and a decrease in pulmonary compliance. There was not standardization of the technique applied or the duration of the intervention.⁽⁸⁾

5. What are the main benefits, contraindications, and possible adverse effects of applying airway clearance techniques?

These techniques improve the SpO₂ of children with chronic or acute ventilatory failure (D)⁽⁷⁾ in the short

term and increase tidal volume in children with acute bronchiolitis (C).⁽⁹⁾

The major contraindications of these techniques include NBs with extremely low birth weight (A)⁽⁴⁾ and cases of gastroesophageal reflux disease (C).⁽⁹⁾

Possible adverse effects include reduced arterial oxygen pressure (PaO₂) (D),⁽⁷⁾ increased respiratory rate, reduced respiratory time, and decreased lung elastic recoil pressure during MH (A).⁽⁶⁾

Rationale

Airway clearance techniques prevent and/or treat airway obstructions caused by the presence of secretions, thereby contributing to the reduction of MPV ventilatory parameters and helping to avoid postoperative complications (e.g., atelectasis) and pulmonary infections. However, the lability of the central nervous system, the weight and gestational age of NBs, and the respiratory mechanics of these techniques should be considered during their indication and application.⁽⁸⁾

GUIDELINES FOR PULMONARY RE-EXPANSION TECHNIQUES

Based on the literature review, the following pulmonary re-expansion techniques were included in these guidelines: 1) MH and its combination with other techniques,^(6,10,12,15) 2) intrapulmonary percussive ventilation,⁽¹⁶⁾ and 3) thoracic compressions followed by slow and complete release of the rib cage (lung squeezing).^(17,18)

6. What should be assessed in NBs and children before, during, and after pulmonary re-expansion techniques?

For the safety of the patients and effectiveness of these techniques, it is recommended to assess at least three of the following parameters before, during, and after their application: demographic characteristics (A),^(6,10,19-21) pulmonary auscultation (A),⁽²⁰⁾ vital signs (heart rate, respiratory rate, and SpO₂) (A),^(4,12,16,17) noninvasive systemic arterial pressure (A),⁽¹⁵⁻¹⁷⁾ arterial blood gas (A),⁽⁶⁾ chest X-ray (A),⁽¹⁶⁻¹⁹⁾ MPV time (A),⁽¹⁹⁾ dynamic and static pulmonary compliance (A),^(6,10,16,18) airway resistance (A),^(6,18) fraction of inspired oxygen (A),⁽¹⁷⁾ plateau pressure (A),⁽¹⁶⁾ average airway pressure (A),⁽¹⁷⁾ inspiratory (B)^(10,12) and expiratory tidal volume (A),^(6,10,16,18) PIF/PEF ratio (B),⁽¹⁰⁾ maximum inspiratory pressure (A)^(10,17) with or without manual vibrocompression (B),⁽¹⁰⁾ average manual force applied

during the MH technique by the physiotherapist (D),⁽¹²⁾ frequency and amplitude of oscillations during manual chest vibration (D),⁽¹²⁾ and duration of the application of the technique(s) (A).^(12,15,17)

Rationale

Respiratory physiotherapy is also intended to maintain and/or increase pulmonary volumes (pulmonary re-expansion), and it includes a variety of techniques and resources to prevent or treat pulmonary collapses (atelectasis), thereby optimizing gaseous exchange and reducing respiratory effort.^(19,21) Re-expansion techniques are used to increase pulmonary volumes by increasing the trans-pulmonary pressure gradient via reducing pleural pressure or increasing intra-alveolar pressure.⁽²¹⁾

The increased oxygenation that occurs after the application of MH results from all of the physiological effects of the technique: removal of secretions combined with alveolar recruitment. The tidal volume applied during MH reaches mainly the regions with greatest pulmonary compliance. Collapsed alveoli are re-expanded through collateral channels and the interdependence phenomenon; this effect explains the need for the evaluation of respiratory and MPV parameters and of respiratory mechanics.⁽²²⁾

7. Are the MH technique with a self-inflating balloon and its combination with other techniques recommended for pulmonary re-expansion?

The application of MH with a self-inflating bag and its combination with other techniques are recommended in neonatology and pediatrics ifor pulmonary reexpansion (A).^(6,10,12,15)

Rationale

During MPV with endotracheal tubes ≤ 3 mm diameter, pediatric patients have increased spontaneous expired tidal volume after endotracheal aspiration followed by MH with a flow of 10 L/min, PIP of 30 cmH₂O, and an inspired oxygen fraction of 100%.⁽⁶⁾

MH combined with manual chest vibration increases PEF and the volume of inspired air; increased PIP increases the lung elastic recoil, favoring the mobilization of secretions throughout the respiratory system and contributing to the re-expansion of collapsed pulmonary areas.⁽¹²⁾ Children aged 6 months to 6 years undergoing MH with a PIP of 40 cmH₂O and PEEP of 15 cmH₂O during 10 cycles/minute showed a lower frequency of atelectasis compared with a continuous positive airway pressure (CPAP) of 5 cmH₂O and the control group.^(3,15)

MH combined with vibrocompression increases PEF by 4% for each 10% increase in the volume of inspiratory air. A 4% increase in the PEF/PIF ratio is related to a manual force of 10 N (force in Newtons).⁽¹⁰⁾

It is necessary to provide a protocol for MH according to each clinical situation to determine air volume, peak pressure to be obtained, PIF and PEF, duration and frequency of application, and the need to use a PEEP valve. The application of MH is inadvisable in patients with PEEP ≥ 10 cmH₂O.

8. Is intrapulmonary percussive ventilation recommended for pulmonary re-expansion?

Intrapulmonary percussive ventilation is recommended for pulmonary re-expansion in children during MPV in a supine position over conventional respiratory physiotherapy (B).⁽¹⁶⁾

Rationale

The utilization of intrapulmonary percussive ventilation for pulmonary re-expansion in children during MPV in a supine position improves the atelectasis score and reduces its time of resolution compared to tapping and vibration.⁽¹⁶⁾ Intrapulmonary percussive ventilation was used with a PIP of 15 to 30 cmH₂O (or the same PIP used for MPV) and a respiratory rate of 180 to 220 cycles per minute with a mean duration of 10 to 15 minutes every 4 hours.⁽¹⁶⁾

9. Are chest compressions followed by the slow and complete release of the rib cage recommended for pulmonary re-expansion?

Performing chest compressions followed by a slow and complete release of the rib cage is recommended in preterm NBs (A).^(17,18)

Rationale

Chest compressions followed by a slow and complete release of the chest/rib cage decreases the time of MPV, oxygen supplementation, and hospitalization.^(17,18)

10. What are the contraindications and possible adverse effects, and which techniques of pulmonary re-expansion are not recommended in NBs, infants, and children?

Pulmonary re-expansion techniques are recommended for NBs, infants, and children suffering from illnesses or clinical conditions that predispose them to pulmonary atelectasis (A)^(4,10,15-17) or clinical

situations with a reduction in pulmonary volumes, a need to increase ventilatory parameters, and/or a deterioration of blood gases (D).⁽¹²⁾

Chest percussion, with or without a mask, after extubation is not recommended in NBs because it can cause the collapse of small airways (A).⁽⁴⁾

Techniques of pulmonary re-expansion are contraindicated in NBs with extremely low birth weight (A),⁽⁴⁾ in thrombocytopenic children with osteopenia or osteoporosis and clinical instability (D),⁽¹²⁾ in children at risk of intra-periventricular hemorrhage and/or with increased intracranial pressure and metabolic bone disease (B),⁽¹⁰⁾ and if air leakage through the endotracheal tube is > 20% (B).^(10,12) Other contraindications include persistent pulmonary hypertension, meconium aspiration syndrome, congenital heart disease with pneumonia (generalized consolidation), immediate postoperative cardiac complication, increased intracranial pressure, hemodynamic instability within the previous 24 hours (20% change in blood pressure, heart rate or in SpO₂), SpO₂ < 85%, pneumothorax, immediate postoperative complication following thoracoabdominal surgery, extreme prematurity or small for gestational age (B),⁽¹⁷⁾ and clinical evidence of foreign body aspiration (C).⁽¹⁹⁾

Possible adverse effects when MH is applied alone in pediatric patients include an increased respiratory rate, decreased lung elastic recoil pressure, and short-term reduction in expiratory time (A).⁽⁶⁾

Children (weight < 3 kg) with atelectasis can present with hypotension during intrapulmonary percussive ventilation (C).⁽¹⁶⁾

Rationale

Alveolar collapse causes a loss in pulmonary volume with a consequent decrease in functional residual capacity and lung compliance, especially in gravity-dependent pulmonary regions. If not reversed, this can unbalance the ventilation/perfusion (V/Q) ratio with functional consequences, including hypoxemia, hypercapnia, increased pulmonary vascular resistance, excessive distention of adjacent alveolar units, risk of infection (nosocomial pneumonia), and pulmonary injury.^(18,19)

GUIDELINES FOR BED PLACEMENT

Based on the analyzed articles, considerations related to bed placement are included in these guidelines as an adjuvant to respiratory physiotherapy for airway clearance

and pulmonary re-expansion in chronically ill NBs, infants, and children during MPV after thoracoabdominal surgeries and during the process of MPV removal.

11. Which positions can be used for infants and children during MPV?

It is recommended to place chronically ill infants and children (cancer and neurological diseases) receiving MPV and with severe respiratory disease (PaO₂/FiO₂ < 200) in an elevated prone position with gel pads at the shoulders and hips (B).^(20,21)

Rationale

During MPV, infants and children with respiratory disease have increased PaO₂ and a reduced oxygenation index when in an elevated prone position, with cushions placed under the hips and shoulders and with the abdomen free.⁽²⁰⁾ During MPV, chronically ill children (cancer and neurological diseases) with severe respiratory disease (PaO₂/FiO₂ < 200) have an increase in PaO₂/FiO₂ of roughly 20% when switched from a supine to prone position for 8 hours, with a reverse effect when switched from a prone to supine position.⁽²¹⁾

Children with respiratory disease and a high oxygenation index exhibit an improvement in oxygenation when placed in a prone position. This result starts within the first 2 hours after the placement and is maintained during the subsequent 12 hours.^(21,22)

In NBs, the response time to the prone position, in terms of oxygenation, is variable, and non-response on the first attempt does not mean a lack of response; however, the initial response can predict subsequent responses.⁽²³⁾

12. Which positions can be used during MPV in NBs and children following thoracoabdominal surgery?

After thoracoabdominal surgeries, we recommend placing infants and children in an elevated prone position with gel pads at the shoulders and hips, as long as precautions are taken to guard the operatory wound (B).^(24,25)

Rationale

Patients in the postoperative period following thoracoabdominal surgery present with increased functional residual capacities when in an elevated prone position with gel pads at the shoulders and hips.⁽²⁴⁾

13. Which positions can be used during the process of MPV removal in NBs and children?

A prone position is not recommended as a routine procedure during weaning from MPV in NBs, infants, and children (B).^(23,25)

Rationale

There was no significant difference in the weaning duration between the prone and supine positions. SpO₂, respiratory rate, heart rate, and incidence of atelectasis after extubation did not differ between the prone and supine positions.^(23,24) NBs, infants, and children in a prone position during MPV should be monitored to avoid unplanned extubation or displacement of the endotracheal tube, catheters, and gastric or bladder tubes.^(26,27) The prone position does not alter mortality rates nor the duration of MPV in infants and children.^(28,29)

GUIDELINES FOR AIRWAY ASPIRATION

Based on the literature review, guidelines are included for aspiration systems (open and closed), the need for analgesia (for pharmacological and non-pharmacological reasons), and for an increase in sedation before, during, and after the procedure of endotracheal aspiration. We also made some relevant considerations regarding the procedure's effects on respiratory mechanics and measures to prevent the adverse effects of endotracheal aspiration in NBs, infants, and children.

14. What are the physiological effects of endotracheal aspiration systems (open versus closed) in neonatology and pediatrics?

We recommend the utilization of the closed endotracheal aspiration system to prevent a decrease of SpO₂ and bradycardia in NBs under conventional MPV and for extremely preterm NBs (B).⁽³⁰⁻³²⁾

Rationale

When the physiological effects of open versus closed endotracheal aspiration systems were compared in NBs under conventional MPV, the results were similar⁽³³⁾ or favored the closed aspiration system, with moderate clinical relevance regarding its effect on SpO₂.^(30,31)

In NBs under high frequency ventilation, there were no significant alterations in SpO₂ when both systems were compared.^(34,35) In NBs under MPV, pulmonary volume was not influenced by the aspiration method.⁽³⁶⁾ When closed and open aspiration methods were compared in extremely preterm NBs under partial ventilation, the closed system provided a greater stability of SpO₂ and heart rate.⁽³⁶⁾

15. What are the effects of analgesia and sedation on stress reactions provoked by endotracheal aspiration in neonatology and pediatrics?

It is recommended that children under MPV with proper sedation not receive sedation prior to aspiration (B).⁽³⁰⁾

In NBs, prior sedation should be carefully judged, and it does not change pain scores (C).⁽³⁷⁾

Multisensory stimulation does not alter pain scores after endotracheal aspiration in NBs (C).⁽³⁸⁾

Rationale

When the sedation score was evaluated during endotracheal aspiration in children under MPV, it was found that this procedure does not alter the level of sedation previously used.⁽³²⁾ In NBs under MPV, the use of sedation prior to the procedure did not influence pain scores as measured using the Bernese Pain Scale for Neonates (BPSN), Premature Infant Pain Profile (PIPP), and Visual Analogue Scale (VAS).⁽³⁷⁾ Multisensory stimulation after the procedure did not alter pain scores in NBs.⁽³⁸⁾

16. Do endotracheal aspiration techniques influence the respiratory mechanics in neonatology and pediatrics?

There are indications that a reduction in pulmonary volume combined with a worsening of pulmonary ventilation and a decrease in SpO₂ may occur in children undergoing conventional MPV after endotracheal aspiration (C).⁽³⁹⁾

A transient decrease of pulmonary volume occurs in NBs under high frequency ventilation after endotracheal aspiration using both closed and open aspiration systems (C).^(34,35)

Alveolar recruitment through a self-inflatable balloon immediately following endotracheal aspiration is not recommended to improve dynamic compliance and expiratory tidal volume of children under MPV (B).⁽³⁹⁾

Rationale

During MPV in children, endotracheal aspiration resulted in a transient and immediate reduction of dynamic compliance and expiratory tidal volume with no effect on airway resistance.⁽³⁶⁾ The utilization of alveolar recruitment through a self-inflating balloon immediately after endotracheal aspiration did not change this profile.⁽³⁹⁾ A reduction in pulmonary volume combined with a retention of arterial carbon dioxide partial pressure (PaCO₂) and a decrease in SpO₂ was also reported.⁽²⁷⁾

17. Should interventions be undertaken to prevent adverse effects of endotracheal aspiration in NBs, infants, and children during MPV?

Hyperoxia (10% increase over baseline fraction of inspired oxygen) is recommended in preterm NBs to avoid hypoxemia during and after endotracheal aspiration to maintain SpO₂ between 88 and 92% (C).⁽³⁸⁾

Postural restraint maneuvers are recommended during aspiration procedures in preterm NBs (C).⁽³⁷⁾

Rationale

In NBs, hyperoxia (a 10% increase over baseline fraction of inspired oxygen) led to favorable effects on the reduction of transient hypoxemia resulting from endotracheal aspiration by an open system.⁽³⁸⁾

Manual restraint maneuvers, through the placement of the hands on the head and feet of NBs in flexed posture, reduced pain scores during the procedure in preterm NBs.⁽³⁷⁾

The criteria in table 2 are suggested to enhance the safety of the procedure, and they indicate that airway aspiration of intubated NBs, infants, and children be performed for a maximum of 10 seconds (to prevent ventilatory and hemodynamic alterations inherent to disconnecting the patient from the MPV apparatus) and that the vacuum suction pressure should not exceed 360 mmHg.⁽⁴⁰⁾

Table 2 - Guidelines for airway aspiration in newborns, infants, and children

| Age | Weight (kg) | Internal diameter of the endotracheal tube (mm) | Secretion consistency and size of aspiration tube (FG) | | |
|----------|-------------|---|--|----------|-------|
| | | | Thin/ fluid | Moderate | Thick |
| NB | < 1 | 2.0 | 5 | 5 | 5 |
| NB | 1 | 2.5 | 5 | 5 | 6 |
| NB | 2 | 3.0 | 5 | 6 | 6 |
| NB | 3.5 | 3.5 | 5 | 6 | 7 |
| 3 months | 6 | 3.5 | 5 | 6 | 7 |
| 1 year | 10 | 4.0 | 6 | 7 | 7 |
| 2 years | 12 | 4.5 | 6 | 7 | 8 |
| 3 years | 14 | 4.5 | 6 | 7 | 8 |
| 4 years | 16 | 5.0 | 7 | 8 | 8 |
| 6 years | 20 | 5.5 | 7 | 8 | 8 |
| 8 years | 24 | 6.0 | 8 | 10 | 10 |

NB - newborn; FG - French gauge. Modified from: Morrow BM, Futter MJ, Argent AC. Endotracheal suctioning: from principles to practice. *Intensive Care Med.* 2004;30(6):1167-74.⁽⁴⁰⁾

To facilitate the appraisal of the multiprofessional team, it is suggested to classify the aspirated secretions as thin or fluid (the aspiration tube becomes free of secretions after aspiration using only the vacuum), moderate (when secretions adhere to the tube wall after aspiration but are removed by saline

solution), or thick (when secretions adhere to the tube wall after aspiration even after the use of saline solution).

GUIDELINES FOR INHALATION THERAPY

Based on the analyzed articles, hypertonic saline solution (HS) at 3% and dornase alfa (rhDNA) were included.

18. In which situations can a 3% HS solution be used in NBs and children?

The use of a 3% HS solution is recommended for infants with viral bronchiolitis for the reduction of the disease symptoms and hospitalization time (A)⁽⁴¹⁾ and for infants with mild to moderate bronchiolitis for the resolution of atelectasis (C).⁽⁴²⁾

The use of a 3% HS solution is recommended for NBs with persistent atelectasis unresponsive to conventional treatment (C).⁽⁴³⁾

Rationale

Aerosol administration allows the direct and immediate availability of drugs in the airways. Drug use through inhalation is an adjuvant to respiratory physiotherapy during techniques for removing secretions from airways and for pulmonary re-expansion.⁽⁴⁴⁾ This technique can only be applied with a medical prescription.

A controlled, randomized, double-blind study⁽⁴¹⁾ assessed the use of inhaled 3% HS solution compared with 0.9% saline solution, both in conjunction with epinephrine (1.5 mg), in 52 hospitalized children with acute viral bronchiolitis. The group that used the 3% HS solution exhibited a decrease in symptoms and time of hospitalization.

One study⁽⁴¹⁾ of children with moderate to severe acute bronchiolitis showed a reduction in hospitalization time and faster relief of symptoms in the group using nebulization with the 3% HS solution compared to groups using the 0.9% saline solution not combined with other drugs. Nebulization with 3% HS is safe, inexpensive, effective, well-tolerated, and has no adverse effects.

A controlled and randomized study⁽⁴²⁾ of 93 infants with mild to moderate bronchiolitis compared the effectiveness and safety of 3% HS solution, salbutamol with 0.9% isotonic saline (SS), and salbutamol on bronchoconstriction, signs of discomfort, and hospitalization time. The group treated with 3% HS solution had a shorter remission time of the bronchoconstriction, remission time of the cough, and hospitalization time.

HS solution is used in NBs with persistent atelectasis unresponsive to conventional treatment because it improves

radiographic scores and SpO₂ and reduces the resolution time of the atelectasis.⁽⁴⁴⁾ In infants with viral bronchiolitis, HS reduces the disease symptoms and hospitalization time;⁽⁴⁴⁾ in infants with mild to moderate bronchiolitis, HS can improve the bronchospasm and signs of respiratory distress and reduce the resolution time of the atelectasis.⁽⁴²⁾

19. In which situations is rhDNA recommended?

rhDNA administered by inhalation or via the endotracheal tube is recommended for non-fibrocystic children with persistent atelectasis (C).⁽⁴⁵⁾

Inhalation is recommended for NBs who do not respond to conventional treatment for atelectasis (D);⁽⁴⁶⁾ for children during MPV in the postoperative period of cardiac surgery subjected to direct instillation in the endotracheal tube; and for infants and children (age <2 years) with acute bronchiolitis submitted to daily inhalation for 5 consecutive days for pulmonary re-expansion (B).⁽⁴⁷⁾

It is recommended for the resolution of pulmonary atelectasis in children during prolonged MPV (C).⁽⁴⁷⁻⁴⁹⁾

Rationale

Drugs called mucolytics break up secretions and cause the lysis of mucofibrils; they are indicated in cases of hypersecretion with increased mucus viscosity. Infection and inflammation of airways as a result from any condition cause significant quantities of extracellular DNA, which is a product of the degeneration of leukocytes and epithelial debris. The DNA increases the viscosity and adhesion of the mucus in the airways. In pulmonary infections aggravated by atelectasis, high concentrations of DNA can be found, thus making the indication of dornase alfa application possible.^(45,48)

rhDNA administered through inhalation is used for NBs who did not respond to conventional treatment for atelectasis, aiming to improve radiological scores and respiratory parameters;⁽⁴⁶⁾ for children during MPV in the postoperative period of cardiac surgery with fluid restriction submitted to direct instillation in the endotracheal tube (dose: 0.2 mg/kg in patients with weight < 5 kg, 0.1 mg/kg for weight > 5 kg; every 12 hours) because it reduces the incidence of atelectasis, the average time of MPV, the average ICU stay, and average costs;⁽⁴⁷⁾ and for infants and children (age < 2 years) with acute bronchiolitis, submitted to daily inhalation for five consecutive days because it yields an improvement in atelectasis score.^(50,51) It can only be applied after medical prescription.

GUIDELINES FOR ASSISTED COUGH

Several interventions of respiratory physiotherapy can be indicated for airway clearance to facilitate secretion removal. Among them, mechanically (mechanical insufflation-exsufflation - MIE) and manually assisted coughing have been indicated for children with impaired effectiveness of the cough because it facilitates the expectoration of secretions from airways when applied alone or combined with other manual or mechanical respiratory physiotherapy techniques.⁽⁵²⁾

20. In which situations is assisted cough indicated and how it can be performed?

It is recommended for children with neuromuscular diseases and acute or chronic respiratory diseases who present with excessive secretions in airways of difficult expectoration and/or pulmonary atelectasis and/or PEF < 270 L/min (B).⁽⁵²⁻⁵⁴⁾

Assisted cough can be manually or mechanically performed (B).^(52,55)

Rationale

Cough is the most common sign and symptom of diseases of the respiratory system.⁽⁵⁶⁾ This reflex is part of the defense mechanism of the airways and can be reproduced and controlled voluntarily or mechanically. Its presence can be correlated to several diseases (e.g., flu, bronchiolitis, tracheitis, and asthma) and can be acute or chronic.⁽⁵⁶⁾

Children with neuromuscular diseases hospitalized in ICUs with an etiology of respiratory disease have a 90% greater risk of morbidity and mortality due to the impossibility of maintaining alveolar ventilation and eliminating secretions from airways because the cough, impaired by the primary disease, becomes less effective in the presence of respiratory diseases and increased volume and consistency of the mucus.⁽⁵⁷⁾

Manually assisted cough through chest or abdomen compression synchronized with the cough performed by the patient increases the PEF, thereby aiding expectoration in cases of mild to moderate cough alterations. Cough assisted combined with MH can increase the effectiveness of the technique.⁽⁵⁵⁾

In a study of MIE application conducted in children with a median (minimum-maximum) age of 12.6 years, the effectiveness of the technique was observed using the following parameters: median (minimum-maximum) insufflation pressure, 30 (15 to 40) cmH₂O and exsufflation pressure, -30 (-20 to -50) cmH₂O; volume, 60 to 100 L/min; PEF, 6 to 11 L/second; and number of respiratory cycles, 3 to 5, with a rest period of 30 seconds before a new IEM application.⁽⁵²⁾

21. What are the possible adverse effects and contraindications of the assisted cough?

The main adverse effects found were abdominal distention, increased gastroesophageal reflux, hemoptysis, chest and/or abdominal discomfort, acute cardiovascular alterations (such as bradycardia), and pneumothorax. The application of these techniques is not recommended in children previously presenting with the clinical conditions mentioned above (B).⁽⁵²⁾

Rationale

The main role of the cough is the detachment and displacement of the material within the airways during the expulsive phase. The detachment of the secretions occurs as a function of the viscosity, elasticity, and thickness of the mucus and its level of adhesion to the airway wall. The flexibility of the bronchial wall facilitates the transmission of an undulation or transient pressure undulation that, when produced by the cough, rapidly displaces the mucus to the mouth.⁽⁵⁸⁾

CLOSING REMARKS

In this article, we have presented the guidelines for several respiratory physiotherapy interventions for patients in neonatal and pediatric ICUs under MPV and within 12 hours following extubation, based on existing evidence. Several techniques applied during respiratory physiotherapy were not

included in these guidelines due to lack of scientific evidence.

The role of the physiotherapist in these areas is broader, requiring continuous development of other guidelines for clinical practice with the aim to improve patient safety.

RESUMO

Recomendações para a atuação do fisioterapeuta em unidade de terapia intensiva pediátrica e neonatal são fundamentais, pois esses profissionais são responsáveis pela reabilitação de pacientes graves. A reabilitação inclui desde a avaliação e prevenção de alterações cinético funcionais às intervenções de tratamento (fisioterapia respiratória e/ou motora), controle e aplicação de gases medicinais, cuidados da ventilação pulmonar mecânica invasiva e não invasiva, protocolos de desmame e extubação, insuflação traqueal de gás, protocolo de insuflação/desinsuflação do balonete intratraqueal, aplicação de surfactante, entre outros. Com o objetivo de propiciar a recuperação do doente e seu retorno às atividades funcionais.

Nesse contexto, essas recomendações têm o objetivo de orientar os fisioterapeutas sobre algumas intervenções de prevenção/tratamento de fisioterapia respiratória (desobstrução das vias aéreas; reexpansão pulmonar; posicionamento no leito; aspiração das vias aéreas; inaloterapia; tosse assistida), que auxiliam no processo de reabilitação de pacientes pediátricos e neonatais em unidade de terapia intensiva em ventilação pulmonar mecânica e até 12 horas após a extubação.

Descritores: Reabilitação; Terapia respiratória; Modalidades de fisioterapia; Terapia intensiva neonatal; Respiração artificial; Criança

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