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Noninvasive ventilation for acute respiratory distress in children with central nervous system disorders

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Summary
Background: Acute respiratory distress (ARD) is a relatively frequent occurrence in patients suffering from central nervous system disorders (CNSD) and moderate to severe mental retardation. Whenever conventional therapy is little effective, noninvasive mechanical ventilation (NIV) is the additional treatment in patients with diseases of the peripheral nervous system. However, NIV is traditionally little employed in the acute phase in patients suffering from CNSD. In the latter, either conventional therapy is maintained or invasive mechanical ventilation is instituted if the patient's condition worsens severely. To challenge the traditional view, we conducted the study to prove that NIV is both applicable and effective in the treatment of ARD also in children with moderate to severe mental retardation.
Methods: We studied 44 children with ARD secondary to pneumonia and CNSD causing moderate to severe mental retardation. The children were divided in two groups. One group received conventional therapy and NIV, the other conventional therapy only, before being advanced to invasive ventilator support when nonresponding. On admission to hospital and one hour following admission we registered pH, $PaCO_2$, PaO2, A − a DO2 and the PaO2/FiO2 ratio. The mean hospital stay was also recorded.
Results: After one hour on NIV PaO2 and pH increased, $PaCO_2$ decreased, A − a DO2 and PaO2/FiO2 ratio improved. No changes in the above parameters were observed in children on conventional therapy only. Hospital stay was shorter when NIV was instituted.
Conclusions: NIV is both applicable and beneficial in stabilizing blood gases, respiratory and cardiovascular parameters also in children with CNSD. Moreover its use shortens the hospital stay.

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Introduction

Children with central nervous system disorders (CNSD) are at increased risk of acute respiratory distress because they often have compromised pulmonary function and ability to handle secretions, which may, in case of viral infection, result in pneumonia [1]. According to Hollins [2] pneumonia accounts for 77% of deaths of patients admitted to hospital for neurological problems. Recurrent aspiration, ineffective cough reflex, reduced or ineffective mucociliary clearance [3,4] are predisposing factors. Other predisposing factors are deformities of the rib cage such as kyphoscoliosis that reduces the vital capacity [5], or the low sensitivity of central and peripheral chemoreceptors as found in Arnold Chiari disease [6]. Diagnosing acute respiratory distress early enough that noninvasive support would be feasible can be made more challenging if a child's degree of cognitive impairment severely limits his or her ability to communicate with care providers [7,8]. When mechanical ventilatory support is required, clinicians have traditionally opted to offer endotracheal intubation because of a perceived inability of children with CNSD to tolerate well noninvasive ventilation. Invasive mechanical ventilation has a number of drawbacks and side effects. It requires deep sedation [9,10], exposes to the risk of ventilator-associated pneumonia, extends hospital stay [11—13], and the child can end up ventilator dependent [14,15]. Therefore in many centers invasive mechanical ventilation is instituted only when there is reasonable expectancy that the patient is weaned off the ventilator. As a consequence many children affected by CNSD are denied ventilatory support in case of acute respiratory distress and are treated solely with antibiotics and oxygen delivered via an ordinary device (face mask or nasal cannula). Taking such decisions in an emergency department, weighing institution guidelines against parents' expectations carries momentous ethical implications [16—19].

There is substantial evidence that noninvasive ventilation (NIV) is safe and effective in the treatment of acute respiratory failure in adults [20] and in children [21]. Therefore, challenging the common attitude we have tested the applicability and effectiveness of NIV in children with CNSD and moderate to severe mental retardation, admitted to a pediatric emergency department for acute respiratory distress from pneumonia.

Methods

This is a prospective nonrandomized nonblinded study.

The study protocol, approved by the ethic committee at our institutions, conformed to the ethical guidelines of the 1975 Declaration of Helsinki as revised in 2000 [22].

Patients

We entered in the study 74 children with CNSD with mental retardation regularly followed up at the unit of pediatric neurology of the department of pediatrics of the teaching hospital Vittorio Emanuele in Catania, admitted to the pediatric emergency department, between May 2010 and June 2012 for an episode of acute respiratory distress (i.e. children with CNSD and tachypnea, dyspnea, retractions, grunting, nasal flaring, apnea, altered mental status, pulse oximetry measurement $<$90 on room air) according to Bradely et al. [15] secondary to very severe pneumonia, as defined by Scott et al. [23].

In nearly 80% of our patients the etiology of pneumonia was viral. However we could not assert how many suffered from concomitant aspiration pneumonia, that is often associated to the infective form.

Study protocol

On admission to the emergency department of pediatrics, both parents of each child were informed of the availability of NIV and of the traditional objections to its use in patients with moderate to severe mental retardation. Informed consent for the use of NIV was requested and if the option was accepted the child entered the Intervention Group (IG). Children of parents refusing consent to the use of NIV formed the Control Group (CG), Fig. 1.

Causes of exclusion from the study were the presence of: mono or bilateral pleural effusion; PaO2 $>$60 mmHg and $PaCO_2$ $<$45 mmHg. mild mental retardation according to International Classification of Functioning Disability and Health — Children & Youth (ICF-CY) [28]. The mental retardation was evaluated on the basis of score for mental retardation (code B117) and score for muscular tone (code B7354) detectable from the medical record of the child. For both tests a score greater than 2 was indicative of the presence of a moderate or severe mental retardation. Appropriateness of the diagnosis of the degree of mental retardation was reassessed individually by two pediatric neurologists by careful examination of patients' charts.

The children of the control group received a conventional treatment with: aerosol therapy with albuterol, i.v. fluids in amounts adequate to maintain a neutral fluid balance, and i.v. antibiotics according to the guidelines suggested by Esposito et al. [24] and Bradley et al. [25]. Oxygen administration via facial mask was instituted, with fraction of inspired oxygen (FiO2) adequate for the levels of SaO_2 (minimum concentration of oxygen that maintains saturations between 88% and 92%) in accord with the guidelines published by Mangera et al. [16].

The children in the intervention group were treated with conventional therapy, as above described, plus noninvasive positive pressure ventilation, with a Bi-Level mode.

For NIV we use a positive inspiratory pressure between 10 and 14 mmHg and positive end-expiratory pressure between 4 and 6 mmHg. The backrest was lifted to an angle of 45°, or the patient was put in a lateral decubitus if unable to sustain a semirecumbent position. A full face mask of adequate size was put in place and Bi-Level NIV started according to British Thoracic Society guidelines [26,27]. Initially the facial mask was hold gently in place by hand and then tightened with tight-fitting securing system when tolerated. Hydrocolloid was used to prevent pressure sores at the bridge of the nose and other points of pressure. The alarm was set monitoring O2 saturation (alarm set for SaO_2 $<$ 90%).