Clinical Reports

Treatment of acute respiratory failure by prolonged non-invasive ventilation in a child

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Purpose: To evaluate the feasibility and the efficacy of non-invasive ventilation (NIV) by nasal mask in a paediatric patient.

Clinical features: A four-year-old girl with acute lymphocytic leukaemia (ALL L_1 pre-pre B) complicated by acute respiratory failure was treated with NIV. On admission she exhibited hyperpyrexia (40C), pancytopaenia and severe hypoxia with hypocapnia (PaO_2 = 45 mmHg; $PaCO_2$ = 28.2 mmHg; pH = 7.30; SpO_2 = 76%; ABE = –7.3 mmol·L^{-1}. With NIV, PaO_2 improved (PaO_2 = 78 ± 8 mmHg; SpO_2 = 86 ± 2; $PaCO_2$ = 39 ± 2) throughout the first day. Treatment was continued for six days until the patient was discharged. No complications were recorded.

Conclusion: Non-invasive ventilation by nasal mask may represent a choice in the treatment of acute respiratory failure of parenchymal origin in paediatric haematological patients.

Objectif : Évaluer la faisabilité et l'efficacité de la ventilation non invasive (VIN) administrée par masque nasal en pédiatrie.

Éléments cliniques : Une fillette de quatre ans atteinte de leucémie lymphocytaire aiguë (ALL L_1 pre- pre B) compliquée d'une insuffisance respiratoire aiguë a été traitée par VIN. À l'admission, elle était hyperpyrexique et profondément hypoxémique avec de l'hypocapnie (PaO_2 = 45 mmHg; $PaCO_2$ = 28,2 mmHg; pH = 7,30; SPO_2 = 76%; ABE = -7;3 mmol·L^{-1}. La première journée, sous VIN, sa condition s'est améliorée (PaO_2 = 78 mmHg; SPO_2 = 86±2; $PaCO_2$ = 39±2). La ventilation a été continuée pendant six jours jusqu'au congé de la patiente. Il n'y a pas eu de complications.

Conclusion : La ventilation non invasive par masque nasal peut représenter une option thérapeutique valable de l'insuffisance respiratoire aiguë d'origine parenchymateuse en hématologie pédiatrique.

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HAEMATOLOGICAL malignancy is often complicated by acute respiratory failure (ARF). This may result from pulmonary localization of primary disease, infection, or cardiogenic pulmonary oedema.

The patient's condition (thrombocytopaenia, pancytopaenia) often discourages aggressive procedures, such as invasive ventilatory support, even though pulmonary function is severely compromised. The mortality rate of haematological patients treated invasively is very high[1-4] and the treatment of paediatric patients affected by ARF is discouraging. The choice of non-invasive ventilation (NIV) in immunocompromized patients could avoid the complications of tracheal intubation (bleeding, barotrauma, infection) which is often deleterious in these patients, with an improvement in the prognosis.

The BiPAP system (Rerspironics Inc, Murrysville,PA) provides a simplified ventilatory assistance for patients with respiratory failure. The device allows continuous positive airway pressure at two levels: End Positive Airway Pressure (EPAP) level, which is equivalent to PEEP and Inspiratory Positive Airway Pressure (IPAP) level, which is similar in function to pressure support. The system may be used in spontaneous mode, similar to pressure support, in a spontaneous/timed mode allowing a backup rate, or in timed mode requiring the setting of an inspiratory ratio. In the spontaneous mode the IPAP is activated by the patient's inspiratory flow and maintained for at least 180 msec, decreasing to the EPAP level when inspiratory flow decreases below a threshold or active expiration is detected (Figure 1).

The ventilator is connected to the patient via a nasal mask (Contour Mask, Respironic Inc., Murrysville, PA). The mask is manufactured in flexible, non traumatic silicone rubber and is perfectly fitted to the face of the patient with low risk of air leaks thanks to a headband. Moreover, utilizing spacers it is possible to reduce the pressure on the bridge of the patient's nose.

We report the case of a four year old patient who was successfully treated with prolonged (one week) NIV following a severe ARF.

Case report

A four-year-old girl (20 kg) with acute lymphocytic leukaemia (ALL L_1 pre-pre B) and in remission after the reinduction phase of therapy with vincristine, adriblastine and dexamethasone came under our care (Table I). She was admitted with a history of fever, vomiting and diarrhoea and exhibited hyperpyrexia (Temp = 40°C), pancytopaenia (WBC 280 mm^{-3}, PLT 11.000 mm^{-3}) and severe hypoxia and hypocapnia (PaO_2 - 45 mmHg, SaO_2 - 76%; $PaCO_2$ - 28.2 mmHg). Hypoxia did not respond to O_2 therapy by Venturi face mask (FIO_2 - 0.5). Respiratory rate was 55 bpm and heart rate 150 bpm. Diuresis was reduced (>10 $ml \cdot hr^{-1}$)and there were intercostal recession, lethargy, abdominal pain and tenderness on physical examination. Arterial blood gas analysis showed severe metabolic acidosis (pH - 7.30; HCO_3 - 19.2 $mmol \cdot L^{-1}$; ABE - -7.3 $mmol \cdot L^{-1}$) (Table II); high levels of lactic acid (17 $\mu mol \cdot L^{-1}$) were detected. Chest X-ray and thoracic CT-scan showed a bilateral, fluffy diffuse infiltrate. Transthoracic echocardiography showed a well maintained kinesis (ejection fraction (EF) > 70%). Blood cultures drawn on fever peaks grew E. Coli; the organism was not identified from the respiratory tract. The patient was treated with appropriate antimicrobial therapy (Ceftriaxone 1 $g \cdot d^{-1}$ e.v.; Amikacine 400 $mg \cdot d^{-1}$ e.v.).

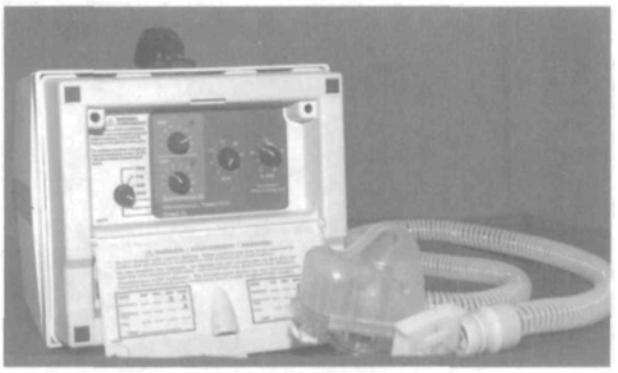

FIGURE 1 The BiPAP system

In addition to antibiotic therapy, the patient was treated with Ranitidine 25 mg tid and total parenteral nutrition with glucose and amino acids through the central venous catheter. No sedation neither analgesia was required.

The diagnosis of Paediatric Acute Respiratory Distress Syndrome (ARDS)[5] was considered to be of septic origin and the patient was admitted to our ICU. Because of the severity of the respiratory distress we chose to start with non invasive ventilation using the BiPAP system after protecting the skin of the nasal bridge with Duoderm® application. Non-invasive ventilatory treatment was started with the following values: spontaneous mode, IPAP - 16 cmH_2O, EPAP - 6 cmH_2O and FiO_2 - 0.5.

Monitoring consisted of ECG, SpO_2 (Biox 3700, Ohmeda), invasive arterial pressure via right radial artery (Venflon 22G, Ohmeda) and blood gas sampling was performed every two hours. Routine laboratory tests were repeated every 12 hr.

TABLE I Therapeuthic regimen

Diagnosis (18/3/93): Acute Lymphocytic Leukemia L1 pre-pre B;
Prognosis: recovery in 60–70%.
Therapy:
First Induction (27/3/93): Vincristine, Daunoblastine,
L - Asparaginase, Prednisone.
Complete Remission: 28/4/93
Second Induction (29/4/93): Cyclophosphamide, Cytarabine,
6 - Mercaptopurine.
Consolidation (14/7/93): 6 - Mercaptopurine, Methotrexate.
Reinduction (6/10/93): Vincristine, Adriblastine,
L - Asparaginase, Prednisone.
Maintenance: Methotrexate, 6 - Mercaptopurine.
End of therapy: 18/5/95

Within the first 24 hr, PaO_2 and SpO_2 rapidly improved (Table I), while her general status deteriorated. Abdominal echography showed acute cholecystitis with left parietocolic fluid collection. Repeat echocardiography showed pump failure with diffuse hypocontractility (EF<35%).

A dopamine/dobutamine infusion was started (7 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and 5 $\mu g \cdot kg^{-1} \cdot min^{-1}$, respectively). Ventilatory support was cycled throughout the following days increasing IPAP and EPAP to 20 and 8 cmH_2O. Treatment was cycled with Venturi oxygen mask (FiO_2 - 0.5) during the day because of: 1) improvement of PaO_2 and SpO_2; 2) intolerance to the mask; 3) up to day 3 feeding and drinking (Table II). The patient responded to antimicrobial therapy and the improved abdominal status allowed surgery to be avoided.

The patient tolerated the mask well so that ventilatory support was continued up to day 7 when the patient was able to maintain SpO_2 of 97% (Table I) by means of a Venturi face mask delivering FiO_2 of 0.4. Daily chest X-rays showed a stable improvement.

On day 9 the patient was discharged to the Department of Hematology and she is now back at school (four year follow-up).

Discussion

This case describes the successful use of prolonged NIV by means of a nasal mask in a paediatric patient affected by ALL in a phase of complete remission, complicated by ARDS of septic origin.

Non-invasive ventilation is commonly used in adult patients as a valuable alternative to standard mechanical ventilation in respiratory failure of central or peripheral neurological origin[6] and for the treatment of recurrent chronic respiratory failures.[7–9] More recently, its use has been reported in patients with acute hypoxaemic respiratory failure.[10–12] There has been little use of the technique in paediatric patients. However, recently, there have been reports of the use of NIV in children with chronic respiratory failure or mild hypoxaemia.[13–15] Akingbola reported the treatment by NIV (BiPAP) in a 12-yr-old boy affected by ALL complicated by acute ARF with good results.[15] This study suggests that NIV could be used successfully in patients with haematological malignancy and ARF.

The outcome of granulocytopaenic patients undergoing tracheal intubation and traditional mechanical ventilation during acute respiratory failure of parenchymal origin is poor.[1–4] Acute respiratory failure is a common complication of haematological malignancy, resulting from the combination of the damage caused by opportunistic infections and the direct interstitial pulmonary toxicity of chemotherapy. Tognet *et al.* reported the successful use of NIV by face mask in six of 11 adults with haematological malignancy complicated by ARF of various origin.[10] In children, non-invasive ventilatory support is an interesting alternative because of the low risk of complica-

TABLE II Mean Values ±SD of daily arterial blood gas analysis.

	pH	*PaO_2 (mmHg)*	*PaC_2 (mmHg)*	*ABE ($mmol \cdot L^{-1}$)*	*HCO3- ($mmol \cdot L^{-1}$)*	*$SatO_2$ (%)*	*Length of treatment Per day (hours)*
Baseline(*)	7.30	43.4	28.2	–7.3	19.2	76	—
Day 1 (**)	7.32 ± .05	78 ± 8	39 ± 2	–4 ± 1	22 ± 2	86 ± 2	22
Day 2 (**)	7.36 ± .03	86 ± 5	41 ± 2	–1 ± 2	24 ± 2	88 ± 1	14
Day 3 (**)	7.36 ± .02	90 ± 4	37 ± 2	–1 ± 1	23 ± 2	94 ± 3	11
Day 4 (**)	7.36 ± .02	110 ± 8	39 ± 2	–2 ± 2	21 ± 2	97 ± 2	8
Day 5 (**)	7.34 ± .04	105 ± 5	37 ± 1	-1 ± 2	24 ± 3	96 ± 2	6
Day 6 (*)	7.32 ± .02	90 ± 4	35 ± 3	-3 ± 2	22 ± 4	94 ± 1	4
Day 7 (*)	7.34 ±. 01	98 ± 4	34 ± 3	-2 ± 1	23 ± 1	95 ± 2	0
Day 8 (*)	7.36 ± .03	110 ± 5	36 ± 2	-2 ± 1	24 ± 1	97 ± 2	0

Arterial blood gas analysis performed during oxygen therapy with standard Venturi oxygen mask FiO_2 - 0.5 (*) and during NIV (**).

tions.[14,15] We have adopted the technique over three years and observed a rapid, effective and stable improvement of arterial oxygenation in 11 of 13 adult patients.[16]

Our young patient suffered from severe sepsis. Because of the underlying disease we chose to avoid aggressive manoeuvres as her bone marrow was in a phase of inactivity. Surgery was delayed and then excluded for these same reasons. By adopting conservative criteria we controlled the critical phase, allowing the bone marrow activity to increase. The respiratory condition was critical. By means of NIV, PaO_2 increased and respiratory rate, heart rate and discomfort decreased considerably within 24 hr. Over seven days, the patient was able to breathe an FiO_2 of 40% via a Venturi oxygen mask without difficulty.

The results we have obtained, in this case, confirm similar studies performed in adults with ARF of various origin including haematological malignancy.[10–12] Therefore, in agreement with Akingbola,[15] we believe that the difference in age does not effect the efficacy of such a treatment. In our case, the patient tolerated the treatment continuously for 24 hr and, then, intermittently for seven days.

The problem of gastric distension during face-mask ventilation has often been emphasized[9] but there was no gastric gaseous distension in this patient, although a naso-gastric tube was avoided in attempt to avoid haemorrhage, inhalation, malpositioning of the nasal mask and skin damage. This is explained by the level of peak airway pressure realized (22 cmH_2O) that is largely below the opening pressure of the upper oesophageal sphincter (30 cmH_2O). The only complication we observed was minor nose skin abrasion after two days of treatment. This could has been avoided with better skin care, although the application of Duoderm® protected the nasal bridge from major skin lesions. The absence of skin damage was probably due to the high quality mask. Moreover, in our opinion, a comfortable mask fit is more important than elimination of every leak by tightening the mask against the face.

In conclusion, NIV by nasal mask may be a valuable tool in the treatment of paediatric patients affected by haematological malignancy complicated by ARF, without risk of major complications.

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