Case Reports

Severe Acute Respiratory Distress Syndrome in a Child With Malaria: Favorable Response to Prone Positioning

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We present the case of a 4-year-old boy with malaria who developed acute respiratory distress syndrome with severe hypoxemia refractory to mechanical ventilation and inhaled nitric oxide. Placing the patient in prone position immediately and persistently improved oxygenation: the ratio of P_{aO_2} to fraction of inspired oxygen rose from 47 to 180 mm Hg and the oxygenation index decreased from 40 to 11. The patient survived, with no respiratory sequelae. *Key words: malaria, acute respiratory distress syndrome, pediatric, prone, supine, hypoxemia.* [Respir Care 2004;49(3):282–285. © 2004 Daedalus Enterprises]

Introduction

Malaria is the most common parasitic infection in the world.[1] The incidence in developed countries is increasing because of nonimmunized travelers to endemic areas[2] and immigration. The severity of the disease increases in relation to the delay between the onset of symptoms and diagnosis and treatment.[2–4] Malaria due to *Plasmodium falciparum* is responsible for the majority of deaths among nonimmune patients, and its treatment should be considered an emergency, as severe complications may appear within a matter of hours.[2]

Acute respiratory distress syndrome (ARDS) may develop as a severe complication of malaria, and ARDS has a high mortality (80%).[2,3,5] Some authors consider ARDS the principal cause of death in children with malaria.[6] There is no specific treatment for ARDS secondary to malaria. The therapies (lung-protective mechanical ventilation, high-frequency oscillatory ventilation, nitric oxide, surfactant, prone positioning) are the same as those used for ARDS secondary to other pathologies.[7] We found no reports on the effect of prone positioning for ARDS secondary to malaria in children.

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Case Summary

A 4-year-old black boy, born and residing in Spain, presented with high fever (up to 40°C) and had shivering and vomiting for 7 days before coming to the hospital. He had been in Senegal 15 days earlier, without receiving malaria prophylaxis. Physical examination was normal except for a 4-cm hepatomegaly and 3-cm splenomegaly. Blood tests showed hemoglobin 7.4 g/dL, platelets 77,000 cells/μL, leukocytes 8,600 cells/μL (75% granulocytes), C-reactive protein 22.6 mg/dL (normal value $<$ 0.5 mg/dL), erythrocyte sedimentation rate 78 mm/h, urea 42 mg/dL, creatinine 0.29 mg/dL, aspartate transaminase 156 international units/L (IU/L), alanine transaminase 81 IU/L, gamma-glutamyl-transpeptidase 46 IU/L, alkaline phosphatase 364 IU/L, and the coagulation study was within the normal range. Malaria was diagnosed by means of a Giemsa-stained blood smear, which showed *P. falciparum*, and immunochromatographic detection of the *Plasmodium* antigen, aldolase, and histidine-rich protein 2. As a confirmatory test we used nested polymerase chain reaction, which was positive for *P. falciparum* and negative for *P. vivax*, *P. ovale*, and *P. malarie*. The parasitemia index was 18%. Because of this high parasitemia percentage we choose intravenous quinine, which required monitoring in the pediatric intensive care unit. Treatment was started with a loading quinine dose of 20 mg/kg, followed by 10 mg/kg every 8 hours for 7 days, which achieved an undetectable parasitemia on the third day of therapy. During the first 2 days of treatment the patient showed progressive anemia and his hemoglobin decreased to 5.2 g/dL, which required transfusion of erythrocyte concentrates (15

mL/kg), from which there were no adverse effects, and his hemoglobin increased to 7.1 g/dL. The platelet count fell to 40,000 platelets/mL, with no clinical signs of bleeding; progressive hepatic dysfunction developed (total bilirubin 7.9 mg/dL, direct bilirubin 6 mg/dL, aspartate transaminase 264 IU/L, alanine transaminase 87 IU/L, gamma-glutamyl-transpeptidase 465 IU/L, alkaline phosphatase 831 IU/L).

Respiratory distress developed 48 hours after admission: the patient had a respiratory rate of 70 breaths/min and progressive hypoxemia, despite oxygen via nasal prongs. The chest radiograph showed bilateral alveolar-interstitial infiltrates (Fig. 1), and 24 hours later the patient required intubation and mechanical ventilation. Clindamycin and meropenem were added at that point and maintained for 6 days, when the negative results of the blood, bronchial aspirate, and urine cultures were known.

The mechanical ventilation was started in a pressure-regulated, volume-controlled mode with tidal volume 8 mL/kg, peak inspiratory pressure 28 cm H_2O, positive end-expiratory pressure (PEEP) 5 cm H_2O, respiratory frequency 30 breaths/min, and fraction of inspired oxygen (F_{IO_2}) 100%, during which blood gas values were pH 7.22, P_{aO_2} 177 mm Hg, P_{aCO_2} 48 mm Hg, and bicarbonate 22 mEq/L, and P_{aO_2}/F_{IO_2} was 177 mm Hg (Table 1).

During the subsequent hours the hypoxemia progressively worsened, as did the radiological signs, which required increases in PEEP (to 15 cm H_2O) and peak inspiratory pressure (to 42 cm H_2O). We began nitric oxide at 10 ppm, but he showed no clinical improvement. The Murray Scale score was 3.75, the dynamic compliance was 4 mL/cm H_2O (0.25 mL/cm H_2O/kg), the P_{aO_2}/F_{IO_2} was 47 mm Hg, and the oxygenation index was 40. At that point we decided to move the patient into the prone position, which we did without interrupting mechanical ventilation, using 4 clinicians to carry out the postural change (one turning the head and endotracheal tube, another turning the trunk, another the legs, and another controlling and mobilizing as necessary the venous and arterial lines). Protective cushions were placed under the shoulders, hips, and ankles to avoid pressure lesions and abdominal compression. No radiographs were taken prior to the postural change nor immediately thereafter, though both hemithoraces were examined carefully.

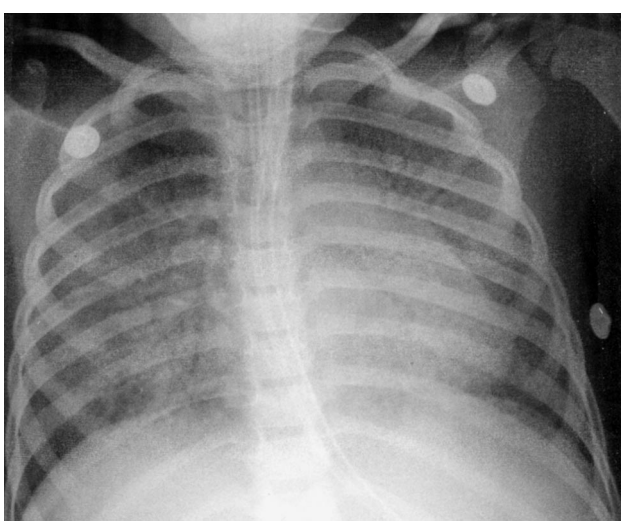

Fig. 1. Anteroposterior chest radiograph taken 3 days after admission, following intubation, showing bilateral diffuse alveolar opacities.

After the change to prone position the patient showed a rapid improvement in oxygenation (see Table 1), with increased dynamic compliance (to 6 L/cm H_2O), which allowed us to rapidly decrease the peak inspiratory pressure and F_{IO_2}. The patient tolerated permissive hypercapnia, with a maximum P_{aCO_2} of 66 mm Hg; this was compensated by the administration of bicarbonate over the first 24 hours, to reach a pH of 7.20.

Twenty-four hours later, given the clinical and blood gas improvement, the patient was returned to the supine position, without disconnecting the mechanical ventilation during the posture change. The posture change led to a renewed worsening in oxygenation, which improved again when the patient was turned back to the prone position (see Table 1), so we decided to keep him prone for 72 hours. The prone position was well tolerated, with no complications or adverse effects. The patient showed a progressive clinical and biological improvement (see Table 1), which eventually allowed us to return him to the supine position, to progressively reduce the respiratory assistance, and to withdraw the nitric oxide after 5 days.

The patient received transpyloric enteral nutrition throughout the course of the illness, and it was well tolerated in both the supine and prone positions. The patient was extubated on the 8th day. Subsequently the patient presented with severe inspiratory stridor, and bronchoscopy revealed subglottic edema and a pediculated tracheal granuloma. The patient required reintubation and dexamethasone therapy at 0.6 mg/kg/d. He was extubated 4 days later and there were no further incidents. He was discharged from the pediatric intensive care unit 16 days after admission, with normal physical examination, blood gas values, and thoracic radiograph, and not requiring oxygen therapy.

Discussion

Of the 4 types of *Plasmodium*, *P. falciparum* produces the most complications and mortality. Early diagnosis and treatment are essential to reduce morbidity and mortality.[3] In our case it was 7 days between the onset of symptoms and the initiation of therapy.

Table 1. Progression of Changes in Respiratory Assistance and Arterial Blood Gas Values

	Before Intubation	After 30 min of Intubation	Before Nitric Oxide	After 30 min of Nitric Oxide	Before Prone Position	After 30 min in Prone Position	After 24 h in Prone Position	30 min After Return to Supine Position	2 h After Return to Prone Position	72 h After Return to Prone Position
F_{IO_2}	Oxygen via nasal prongs	1.0	0.6	0.8	1	1	0.75	0.75	0.7	0.4
PIP (cm H_2O)	NA	26	28	32	42	38	38	38	36	30
PEEP (cm H_2O)	NA	5	5	7	13	15	15	15	15	10
V_T (mL/kg)	ND	7.5	7.5	7.5	11.5	8	6.2	6	6	6
f (breaths/min)	ND	25	30	30	30	30	35	35	35	40
pH	7.43	7.22	7.26	7.22	7.40	7.34	7.37	7.35	7.48	7.48
P_{aO_2} (mm Hg)	110	177	72	61	47	180	96	41	64	96
P_{aCO_2} (mm Hg)	32	48	51	57	35	40	54	63	63	49
HCO_3^- (mEq/L)	22	22	23.8	24	22	22	34	34	35	35
P_{aO_2}/F_{IO_2} (mm Hg)	ND	177	120	76	47	180	128	54	91	240
OI	ND	7.3	12.5	20.9	40	11	15.6	36.5	20.7	8.7

F_{IO_2} = fraction of inspired oxygen
PIP = peak inspiratory pressure
NA = not applicable
PEEP = positive end-expiratory pressure
ND = no data available
V_T = tidal volume in mL per kg predicted body weight
f = respiratory frequency
OI = oxygenation index (mean airway pressure $\times F_{IO_2} \times 100/P_{aO_2}$)

The incidence of ARDS as a complication of malaria is lower in children than in adults. ARDS develops more frequently in those patients who have the most severe forms of the disease and is associated with other complications.[3] There are no known variables that enable us to predict the onset of ARDS in malaria. Some authors have found a higher percentage of parasitemia among patients who develop ARDS, as occurred in our case, but the correlation between percentage of parasitemia and ARDS was not confirmed in subsequent studies.[3]

The pathogenesis and pathophysiology of ARDS secondary to malaria are still unclear,[2] although they may be due to a pulmonary microvascular dysfunction secondary to the liberation of inflammatory mediators, which increase vascular permeability. It has also been suggested that mature *P. falciparum*-parasitized erythrocytes sequester from the circulation by adhering to the microvascular endothelial cells. Parasitized-erythrocyte sequestration contributes to the virulence of *P. falciparum* malaria.[8] Our patient presented with severe ARDS caused by *P. falciparum* and had hypoxemia refractory to pressure-controlled mechanical ventilation with low volumes and high PEEP, and inhaled nitric oxide. Prone positioning rapidly and substantially improved the hypoxemia, improved the P_{aO_2}/F_{IO_2} ratio, and decreased the oxygenation index, which permitted relatively low ventilator settings and led to progressive improvement and resolution of the disease process.

The prone position is a simple, effective, and safe strategy that has few adverse effects and that improves oxygenation by as much as 80% in certain ARDS patients.[9] However, there is still no evidence that the prone position improves prognosis of ARDS patients. The only randomized, controlled study with adult subjects showed no mortality benefit from prone positioning.[10] There have been studies on prone positioning of pediatric ARDS patients[9,11] but we found no references to the effect of prone positioning in malaria-induced ARDS.

The mechanism by which prone positioning improves oxygenation is not fully understood. The mechanism is at least partly that it opens alveoli in the posterobasal lung regions, which are collapsed in the supine position by the weight of the rest of the lung and the heart. Other mechanisms may also be important, such as redistribution of blood flow (which might improve ventilation-perfusion matching), increase in the final expiratory volume, and improved pulmonary compliance.[12]

In our patient, who had very severe ARDS that required a very high PEEP and did not improve with nitric oxide, the prone position immediately and markedly improved oxygenation and moderately increased compliance, which allowed a decrease in mechanical respiratory assistance. The effect of prone positioning did not decline over 72 hours.

There is no consensus on the recommended duration of prone positioning: recommendations have ranged from 2 to 24 hours among various authors,[12,13] though some studies report greater oxygenation improvement with $>$ 12 hours.[14] Our practice with patients who favorably respond

to prone positioning is to maintain the prone position for 12–24 hours, testing thereafter whether the supine position is tolerated. Some patients are prone-dependent and worsen if returned to supine position, as happened initially in our patient, causing us to return him to the prone position for 72 hours (during which we saw no adverse effects). In cases that require prolonged prone-position ventilation, regular examination is essential to prevent pressure lesions of the face and skin, and protective cushions, colloid dressings, and postural changes of the head and limbs are used. Transpyloric enteral nutrition is well tolerated, as observed in our patient, and can reduce the risk of vomiting and aspiration associated with the gastric compression caused by the prone position.

Conclusions

We conclude that the prone position can be a simple and useful therapeutic measure to improve oxygenation in ARDS secondary to malaria, and that prone positioning should be employed early in those patients who do not improve with mechanical ventilation.

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