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ARDS Secondary to Descending Necrotizing Mediastinitis Treated By Long-Term Extracorporeal Respiratory Support

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Introduction

Acute respiratory distress syndrome (ARDS) may be a severe complication of descending necrotizing mediastinitis (DNM) that dramatically increases mortality in conventionally treated patients.[1] Extracorporeal respiratory support in case of ARDS secondary to DNM represents a hard challenge, as a very severe clinical condition is treated with a complex technique. Here we describe a case of ARDS secondary to a DNM managed with veno-venous extracorporeal membrane oxygenation (ECMO).

Case Summary

A 28-year-old previously healthy man (weight 90 kg, height 180 cm) was referred to our hospital for a septic condition associated with an odontogenic abscess. Despite abscess drainage and empiric broad-spectrum antibiotics, the patient developed a severe respiratory failure secondary to descending mediastinitis. A chest computed tomography (CT) scan showed that the infection was extending to the lower anterior and posterior mediastinum (type IIB DNM, according to Endo et al's classification)[2] (Fig. 1).

The patient underwent surgical treatment, which consisted of debridement of necrotic tissue and drainage of infected fluid collections through a neck collar incision and right thoracotomy. Then he was transferred to the postoperative ICU. Subsequently, the patient developed a progressive impairment of gas exchange and ARDS (P_{aO_2}/F_{IO_2} 170 mm Hg, pH 7.31, P_{aCO_2} 74 mm Hg). Volume controlled ventilation with lung-protective strategy (plateau pressure < 30 cm H_2O) was adopted: tidal volume (V_T) < 6 mL/kg, respiratory rate 20–22 breaths/min, and PEEP 10 cm H_2O. Nevertheless, respiratory acidosis worsened until pH dipped to 7.23, with P_{aCO_2} 90 mm Hg. Therefore, an extracorporeal veno-venous respiratory support with CO_2 removal (DECAP CO_2 Remover, Estor, Pero, Milano, Italy) was started. Six days later, since clinical conditions and gas exchange were not improved (P_{aO_2}/F_{IO_2} 150 mm Hg, pH 7.31, P_{aCO_2} 72 mm Hg, compliance

Fig. 1. Multiplanar reconstruction reformatted on oblique sagittal plane, demonstrating the abscess progression through the cervical spaces, down into the mediastinum and the retrosternal space (arrowhead) and posterior mediastinum (asterisks).

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The authors have disclosed no conflicts of interest.

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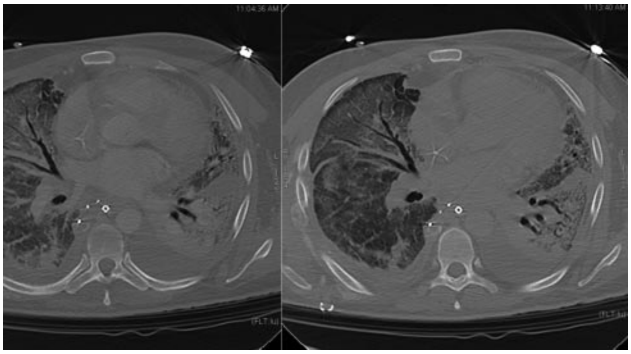

Fig. 2. Thin section chest computed tomogram performed with different PEEP values, demonstrating poor recruitment of lung parenchyma in ARDS condition.

25 mL/cm H_2O), the patient was transferred to our ICU for ECMO treatment.

Clinical data at admission were: body temperature 35.5°C, arterial pressure 140/75 mm Hg, heart rate 112 beats/min. Laboratory tests showed leukocytosis (14,000 cells/mL) and increase of both C-reactive protein (18 mg/mL) and procalcitonin (4 ng/mL). CT scan revealed a massive bilateral consolidation of the lungs, unresponsive to recruitment maneuvers. The maneuvers were performed by changing the ventilator mode to continuous positive airway pressure and rapidly increasing the PEEP level up to 40 cm H_2O for 40 seconds. During the recruitment maneuver, the maximum peak airway pressure tolerated was 40 cm H_2O. The procedure was stopped in case of hypotension (systolic arterial pressure < 90 mm Hg) or severe hypoxemia ($S_{pO_2} < 80\%$) (see Fig. 2). The arterial blood gas analysis during CO_2 removal showed hypoxemia (P_{aO_2}/F_{IO_2} 140 mm Hg) and respiratory acidosis (pH 7.30, P_{aCO_2} 70 mm Hg). In spite of severe signs of infection, no microorganisms were isolated in any sites or in surgical drainage fluid, and the patient was empirically treated with teicoplanin and amikacin.

For one day CO_2 removal, protective ventilation, and recruitment maneuvers were continued, but despite protective ventilatory settings (volume controlled ventilation with V_T 6 mL/kg, respiratory rate 24 breaths/min, PEEP 14 cm H_2O) we didn't obtain a reduction of plateau pressure, which started to overcome 30 cm H_2O (32–35 cm H_2O) as the static pulmonary compliance was decreased to 10 mL/cm H_2O. Gas exchange and respiratory acidosis worsened until P_{aO_2}/F_{IO_2} of 90 mm Hg, P_{aCO_2} of 85 mm Hg, and pH of 7.28. Therefore, we decided to switch the extracorporeal respiratory support into a veno-venous ECMO through a veno-venous percutaneous femoro-femoral bypass. After systemic heparinization, two 21 French cannulas were inserted: one from the right femoral vein, with the tip in right atrium, the other from the left femoral vein with the tip in the inferior vena cava. The venous blood, driven by a centrifugal pump (Jostra Rotaflow, Maquet Cardiopulmonary, Hechingen, Germany), was drained from the inferior vena cava, pumped through an artificial lung (Jostra Quadrox PLS, Maquet Cardiopulmonary, Hechingen, German), and then re-infused into the right atrium. Extracorporeal blood flow was set to 3.5 L/min and artificial lung gas flow to 7 L/min. A pulse contour system (MostCare, Vytech/Vygon Italia, Padova, Italy)[3] provided hemodynamic monitoring. Anticoagulation was achieved with unfractionated heparin infusion titrated to obtain an activated partial thromboplastin time of 65–80 seconds. During the first days the respiratory dead space was 90%; thus, with ECMO support, we could set a volume controlled ventilation with a $V_T < 4$ mL/kg, PEEP of 20 cm H_2O (maintaining plateau pressure < 30 cm H_2O), respiratory rate of 8 breaths/min, and F_{IO_2} of 1.0, achieving a gradual correction of respiratory acidosis (P_{aCO_2} 45 mm Hg, pH 7.46) and a moderate improvement of oxygenation (P_{aO_2}/F_{IO_2} 150 mm Hg).

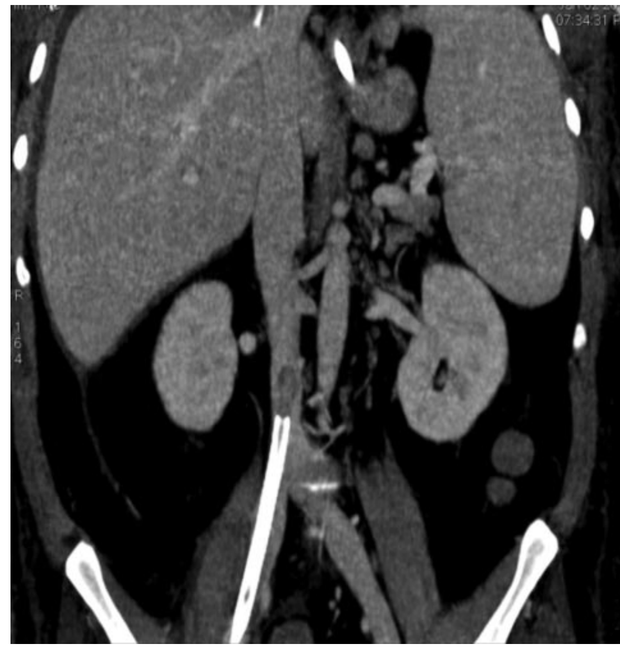

Fig. 3. Multiplanar reconstruction reformatted on coronal planes shows venous thromboses associated with catheter at first extracorporeal membrane oxygenation catheter placement.

On the 4th day, bronchoalveolar lavage and blood culture were positive for a multiple-drug-resistant *Pseudomonas aeruginosa*. Treatment with teicoplanin was stopped, and a combined therapy with intravenous meropenem and intravenous plus endobronchial amikacin was started.

On the 14th day, despite heparin and antithrombin III continuous infusion to guarantee a stable antithrombin III activity $> 80\%$, a drop of blood flow occurred. No clots in the external circuit were detected, and a CT scan showed the presence of a blood clot in the in-flow cannula (see Fig. 3). Therefore, we replaced both the cannulas with 2 of

Fig. 4. Extracorporeal membrane oxygenation catheter thrombosis after second placement.

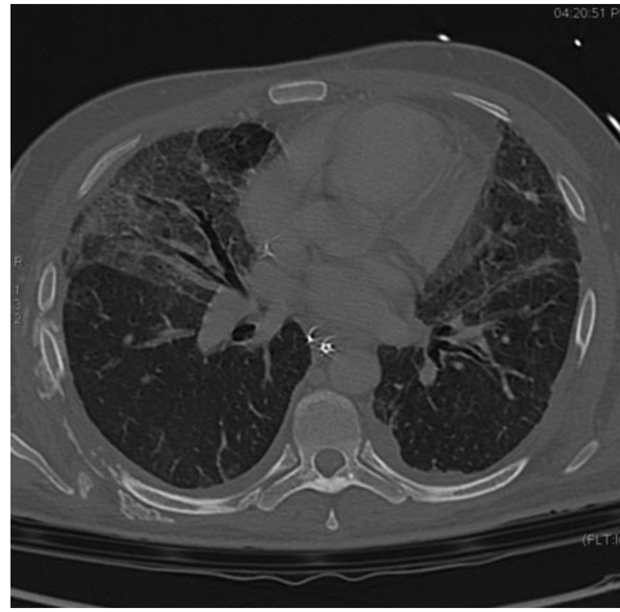

Fig. 5. Thin section chest computed tomogram performed before discharge, demonstrating partial resolution of ARDS condition with fibrosis evolution.

a larger caliber (23 French). Eight days later the cannulas were replaced again because of new clot formation (Fig. 4). On this occasion a systemic coagulation screening demonstrated heparin-reactive antibodies, with a weak activity not inducing platelet aggregation. After this episode no other problems with the cannulas occurred. On the 20th day a bronchoalveolar lavage positive for a carbapenems-resistant *Pseudomonas aeruginosa* required a modification of therapy to ciprofloxacin and aerosolized colistin. The stay of the patient was complicated by acute cholecystitis, empirically treated with intravenous tigecycline and afterwards, on the 21st day of ECMO, with a cholecystotomy. Subsequently, ventilatory parameters gradually improved along with clinical conditions: on the 23rd day P_{aO_2}/F_{IO_2} 170 mm Hg, pH 7.45, P_{aCO_2} 43 mm Hg, compliance 28 mL/cm H_2O.

A new CT scan performed on the 25th day showed a substantial improvement of mediastinal and pulmonary framework (Fig. 5). The patient was weaned from ECMO after 34 days, and from mechanical ventilation 23 days later. Antibiotic therapy was discontinued on the 50th day of stay. He was transferred from the ICU to the Department of Respiratory Physiopathology for rehabilitation, 65 days after admission. He was discharged from hospital 14 days later, with a vital capacity of 50% of predicted.

Discussion

DNM resulting from necrotizing fasciitis of the neck is a rare and serious disease, which has a dramatic prognosis and a mortality that varies in the literature from 14% to 50%.[1] One of the most common complications is lung involvement, directly, through the extension of the inflammatory process, and/or indirectly, through the establishment of a septic state.[4] Even with early diagnosis and the institution of an appropriate medical and surgical therapy, mortality remains high. A meta-analysis showed that for a second type IIB mediastinitis, surgical treatment with cervicotomy was burdened with a mortality of 47%, compared with 19% among the patients treated with cervicotomy and thoracotomy.[5] In this scenario, the target of early diagnosis and effective treatment is to minimize as much as possible the mortality.[6]

Together with surgery, an aggressive medical therapy, aimed at the treatment of primary infection and management of the complications associated with the disease, is mandatory. In our patient the conventional treatment of ARDS was not sufficient to ensure adequate control of either acidosis or pulmonary pressures. Respiratory support with CO_2 removal was therefore considered because it is relatively simple to establish[7] and to manage. It consists of a veno-venous shunt system, with a circuit similar to that of continuous renal replacement therapy. However, the technique, given the low blood flows (approximately 400 mL/min), provides a limited removal of CO_2 and cannot enhance blood oxygenation. Furthermore, a daily replacement of the circuit is needed.

In our patient this approach became insufficient when the clinical conditions worsened. Veno-venous ECMO, by supporting greater blood flows (0.5–7 L/min), allows greater CO_2 removal and can provide blood oxygenation.

Initially, given the size of the cannulas (21 French), the contribution to oxygenation was low (P_{aO_2} 65 mm Hg). In fact, we obtained blood flows of about 3–3.5 L/min, which accounted for half of the cardiac output of our septic patient. However, the blood flow was still sufficient to ensure adequate CO_2 removal and, consequently, an over-protective controlled ventilation ($V_T < 4$ mL/kg), which was our primary intention. During the first period, an F_{IO_2} of 1.0 and daily recruitment maneuvers were indispensable to maintain an acceptable oxygenation (pronation of the patient was avoided, given the presence of the chest drainages).[8]

Pulmonary artery catheter is necessary for monitoring hemodynamics as well as the proportion of shunt, the mixed venous saturation, and the ratio of cardiac output to blood flow during an ECMO treatment. However, the site of the infection and the surgery wounds made us desist from inserting a pulmonary artery catheter. Thus, hemodynamic parameters were obtained by transthoracic echocardiography and by the pulse contour system,[3] which allowed us continuous cardiac output monitoring. Therefore, we could set blood flow in relation to cardiac output changes, monitoring "online" the cardiac output/blood flow ratio.

After 7 days of ECMO support, P_{aCO_2} was 58 mm Hg and pH was 7.42. On the 14th day the 21 French cannulas were replaced with larger cannulas (23 French) because of the presence of blood clots. This allowed us to increase the extracorporeal blood flow up to 4.5 L/min, with a consequent improvement of blood oxygenation. The cannulas were replaced another time for the same reason, in spite of a constant control and optimization of coagulation assessment (heparin and ATIII infusion, blood products transfusions). The blood tests showed the absence of functional heparin reactive antibodies, so this condition was probably secondary to the sepsis-related impairment of coagulation.[9]

Teaching Points

- Our experience confirms that ECMO treatment is subject to several potential complications and requires a skilled staff. Considering the high mortality rate reported among patients with respiratory failure related to DNM and sepsis, this treatment should be considered in the early stage of the disease.
- CO_2 removal does not allow oxygenation and, given the low blood flows, is unable to remove a large amount of CO_2. However, in selected patients it may be a valuable aid if applied very early.
- Extracorporeal assistance may enhance the coagulation impairment due to sepsis.

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