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Case Report

The double-edged sword: increased hemolysis following the addition of an oxygenator to the Berlin heart for respiratory support

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ABSTRACT

Integrating oxygenators into Berlin heart ventricular assist devices (VADs) for pediatric patients with heart failure and respiratory compromise can be lifesaving but may lead to significant complications, including increased hemolysis. We present two pediatric cases that highlight the challenges of oxygenator use in Berlin heart VADs, focusing on hemolysis, clinical interventions, and patient outcomes. In both cases, the integration of an oxygenator resulted in elevated plasma-free hemoglobin and bilirubin levels, indicative of hemolysis. Following the removal of the oxygenator, these laboratory abnormalities resolved, and clinical status improved. These cases underscore the potential risks associated with oxygenator integration into Berlin Heart VAD circuits and emphasize the importance of close monitoring, timely recognition of hemolysis, and individualized decision-making regarding the duration of oxygenator use.

Keywords: Ventricular assist device, Berlin heart, Oxygenator, Hemolysis

INTRODUCTION

Berlin heart ventricular assist devices (VAD) is an effective tool for bridging children with heart failure to transplantation, with relatively few complications.[1] Berlin heart VAD combined with oxygenator has been effective in patients with biventricular support.[2] This combination has also been used successfully as a bridge to pediatric heart transplantation in patients with severe heart and respiratory failure.[3-5]

CASE REPROTS

Case 1

An 8-year-old male patient presented with dilated cardiomyopathy, whose condition continued to deteriorate despite optimal medical management. Three months following presentation, a Berlin heart LVAD was implanted. Six months later, the patient experienced clinical deterioration with right ventricular (RV) failure, requiring intubation and mechanical ventilation. Given his expected prolonged wait for a transplant, the decision was made to proceed with Berlin heart RVAD implantation. Due to congestive lung changes, an oxygenator was placed in the RVAD outflow (Figure 2). Immediately after adding the oxygenator, the patient developed significant hemolysis manifested by increasing total bilirubin and jaundice (Figure 1). The oxygenator was subsequently removed six days later. A few days after the oxygenator was removed, the patient's bilirubin levels decreased (Figure 1), and the jaundice resolved.

Unfortunately, the patient developed cerebral bleeding during his hospitalization afterward and eventually passed away.

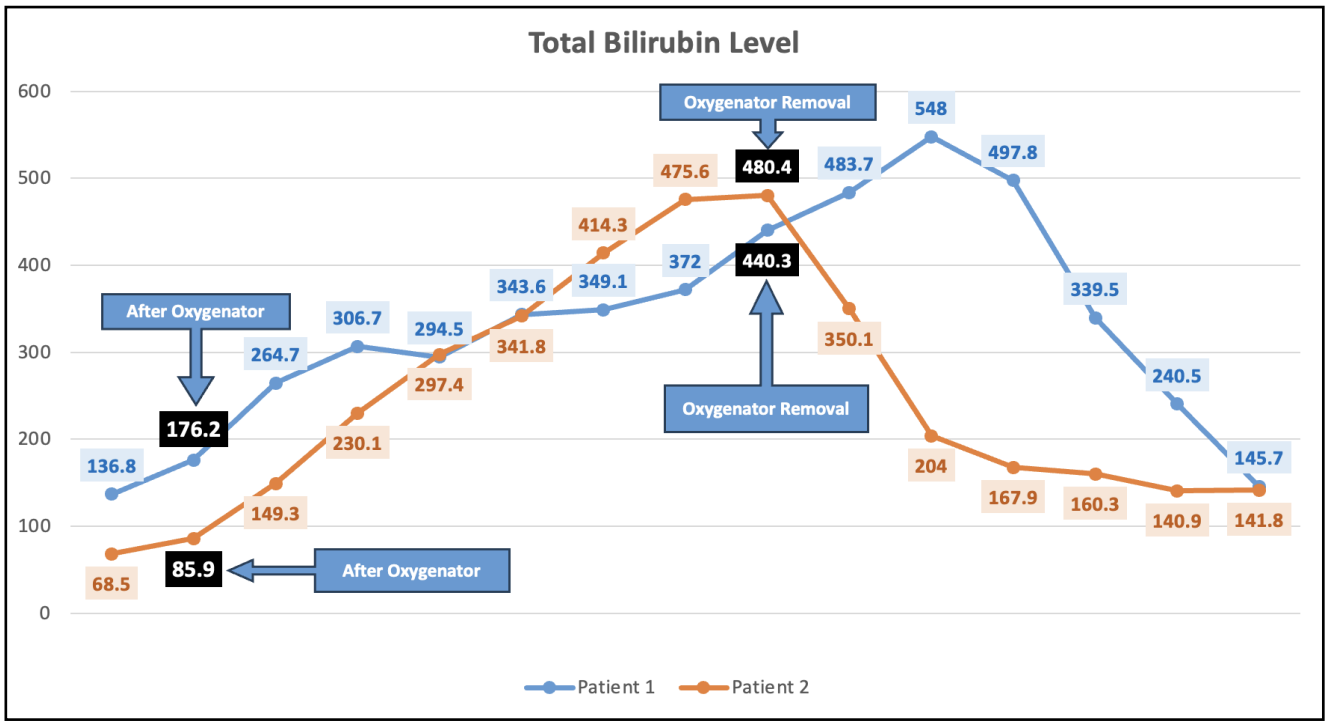

Figure 1: Total bilirubin trends for patient 1 and 2.

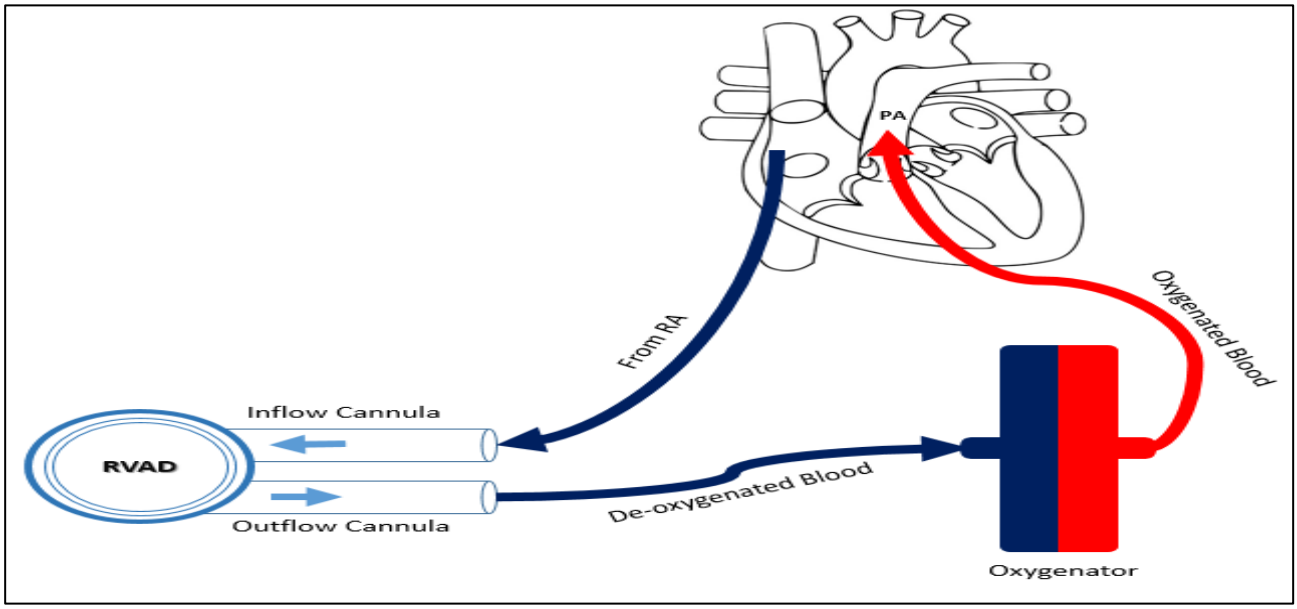

Figure 2: Schematic diagram illustrating the configuration of the Berlin heart RVAD with an inline oxygenator. The oxygenator inlet is connected to the outflow of the RVAD to supply the oxygenator with deoxygenated blood, and the oxygenator outlet is connected to the already implanted outflow cannula to return the oxygenated blood.

Case 2

A 2-year-old female patient had dilated cardiomyopathy, likely caused by a viral infection. Echocardiography revealed a severely reduced ejection fraction of 25% and dilated ventricles. She was admitted to the pediatric intensive care unit and continued standard heart failure medications.

During the pediatric ICU admission, the patient suffered a cardiac arrest, and central Veno-arterial extracorporeal membrane oxygenation (VA ECMO) was initiated. Later, the ECMO was replaced by A CentriMag biventricular assist device using a Berlin heart cannula, and after two weeks, the Berlin heart pumps were inserted.

During the hospital course, the patient developed a *Candida* infection and required ventilator support. An

oxygenator was added to the patient's right Berlin heart device to help manage her persistent high carbon dioxide levels and significant acidosis. Shortly after the oxygenator was installed, the patient began experiencing significant hemolysis, indicated by rising total bilirubin levels and jaundice. After resolution of the acute phase of respiratory infection, the oxygenator was removed eight days later. A few days after the oxygenator was removed, the patient's bilirubin levels decreased (Figure 1), and the jaundice resolved. The patient was extubated a few days later and underwent a heart transplant three months thereafter, currently maintaining stable condition.

DISCUSSION

Incorporating an oxygenator into Berlin heart VAD strategic approach to enhance respiratory support for these critically ill patients.[2] Ability to augment pulmonary function in this way, in conjunction with Berlin heart's VAD, represents a critical therapy for these patients suffering from severe cardiac and respiratory failure.[2]

The cases underscore the difficulty of integrating an oxygenator into a Berlin heart VAD, resulting in significant hemolysis that may cause serious clinical complications such as anemia and renal impairment.[3]

The root cause of the increased hemolysis appears to be the increased resistance across the oxygenator.[6] During the systolic and diastolic phases of the pumping cycle, the rapid flow of blood through the oxygenator creates high shear stresses on the red blood cells, leading to cell membrane lysis and hemolysis.

Red blood cells are particularly susceptible to mechanical damage from high shear stresses. When these cells are subjected to intense and prolonged shear forces, their cell membranes can rupture, releasing hemoglobin into the plasma-the hallmark of hemolysis.[7-10]

Severe hemolysis associated with oxygenators poses a considerable risk to vulnerable patients. VV ECMO may mitigate hemolytic stresses; however, maintaining anticoagulation balance presents challenges. A thorough assessment and interdisciplinary discussion are crucial for determining the optimal respiratory support strategy.

CONCLUSION

A thorough assessment of the individual patient's condition, risks, and potential benefits would be necessary to determine the optimal approach for providing respiratory support in conjunction with the Berlin heart VAD.

A multidisciplinary team discussion weighing the pros and cons of the different options would be prudent to determine the best course of action for these complex cases.

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