Synergy between stents and extracorporeal membrane oxygenation in multitrauma patients with inferior vena cava injury

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Abstract
Despite the lack of evidence in the literature, we report the case of a 25-year-old man involved in a road traffic accident, who had an inferior vena cava (IVC) injury and severe lung contusion with parenchymal bleeding requiring an extracorporeal membrane oxygenation (ECMO). An emergency procedure to implant a stent graft was successful in repairing the IVC injury. Moreover, we think that EOMO, in addition to providing oxygenation, reduced bleeding by creating a negative pressure along the injured IVC. The patient was decannulated on the eighth day and discharged 31 days after the accident.

Keywords: Acute respiratory distress syndrome • Bleeding • Inferior vena cava injury • Extracorporeal membrane oxygenation • Endovascular procedures/stents

INTRODUCTION
Inferior vena cava (IVC) injuries are a well-known life-threatening entity in multitrauma patients. Conventional open repair of traumatic injuries of IVC still represents a surgical challenge, since it carries high morbidity and mortality rates in an emergency setting.

Increased mortality in the early period is related to the following complications: hypovolemic shock and/or severe respiratory failure following chest trauma or massive blood transfusions, which can lead to acute respiratory distress syndrome (ARDS). The mortality rate in these patients reaches up to 40% despite advanced ventilatory treatment. Extracorporeal membrane oxygenation (ECMO) can be effective in severe cardiopulmonary failure, but pre-existing bleeding is still a contraindication for its use.

CASE REPORT
The authors report the case of a 25-year-old male patient who was involved in a high-velocity road traffic accident. Clinical examination and first-line imaging showed severe thoracic trauma and an haemoperitoneum. A thoracic and abdominal computed tomography (CT) scan revealed a juxtahepatic IVC injury, extending from the hepatic vein to the junction with the right atrium and a bilateral lung contusion (Fig. 1).

Emergency exploratory laparotomy and liver packing were performed. Over the first postoperative hours, ARDS developed. An ECMO was therefore needed, but repeated abdominal CT scan showed persistent bleeding. A new surgical intervention was considered extremely hazardous, so, after a multidisciplinary consultation, we decided to implant a stent graft (SG) to repair the IVC injury, allowing the positioning of an ECMO cannula.

A stenting procedure under fluoroscopy guidance was successfully performed using two short paediatric prostheses (NuMED Covered CP Stent™, CP8Z39 and CP8Z45, NuMED, Inc., NY, USA; Fig. 2A). Therefore, a veno-venous femoro-jugular ECMO was established. Under cavography, the tip of the drainage cannula in the left femoral vein was positioned below the bottom of the stents, in order to maintain a negative pressure along the IVC, aiming to decrease the bleeding (Fig. 2B). The reinsertion site was through a percutaneous cannulae placed in the superior right jugular vein. The blood gas was then gradually corrected with an initial ECMO flow of 2 l/min and 100% FiO2.

After 24 h, ECMO flow could be increased to 4.5 l/min for optimal oxygenation, leading to lower FiO2 requirements (71% after 36 h, 50% after 72 h and 35% after 5 days).

Five days later, a new CT scan was performed and showed a significant improvement in ARDS and the correct position of the IVC stents, with adequate permeability and no evidence of paraprosthetic leaks (Fig. 2C). On postoperative day 8, ECMO could be removed. The liver packing was removed on postoperative day 9, with no re-bleeding complications. After 31 days in the intensive care unit, the patient could be transferred to the rehabilitation service. An antithrombotic treatment by antiplatelets (acetylsalicylic acid) was followed over 6 months. At 15-month
follow-up, a CT scan showed the two covered stents in the IVC still in place, with an optimal intraprosthetic permeability.

**DISCUSSION**

Few data exist concerning the management of traumatic IVC injuries even if they can be associated with a high mortality rate (50–80%) [1]. In vascular trauma, surgical treatment can be prolonged, presents technical difficulty regarding access, requires massive blood transfusion and may be complicated by infection or thrombo-embolic complication.

Interventional vascular techniques are becoming a useful alternative approach in the treatment of traumatic vascular injuries, even if scarce evidence is available. A small number of authors report the intravascular procedure as a safe method. Castelli et al. [2] recorded a successful case of endovascular repair for IVC injury. A more recent study in animal models shows encouraging results [3]. The main advantages include the speed of the approach, combined with minimal additional tissue trauma, important for bleeding control.

Adult multitrauma patients are at risk of respiratory failure. The guidelines for the treatment of ARDS include ventilation with low tidal volume and plateau pressure, ventilation with positive pressure, manoeuvres to increase alveolar recruitment, prone positioning and use of nitric oxide.

ECMO allows the reduction in ventilator settings and limits further barotraumas while maintaining tissue perfusion and oxygenation. It is an evidence-based treatment for severe respiratory failure, but its role in trauma patients is less well defined due to the need for anticoagulation. Cordell-Smith et al. [4] proposes the use of limited anticoagulation with intravenous heparin.

Arlt et al. [5] used a new miniaturized ECMO device (PLS-Set, MAQUET Cardiopulmonary AG, Hechingen, Germany) and initially performed heparin-free ECMO. In our case, we primarily contraindicate the use of ECMO, because of the active bleeding, but after a multidisciplinary consultation, we hypothesized that the use of covered SG would decrease the bleeding, and that

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**CASE REPORT**

S. Filippini et al. / European Journal of Cardio-Thoracic Surgery 1141

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**Figure 1:** CT scan of the chest and abdomen showing a large issue of contrast from the IVC (arrow).

**Figure 2:** (A) Cavography after the positioning of two covered stents in the IVC before ECMO cannulation. The stents are in Dacron that explains para-prosthetic leaks, still visible immediately after the procedure. (B) A CT scan showing the relationship between the position of the ECMO cannula and the stents. (C) Five-day CT scan showing the correct position of the IVC stents, with adequate permeability and no evidence of paraprosthetic leaks.
the establishing of an ECMO performed without heparin, thanks to the use of heparinized-coated circuits, would help the oxygenation improve and in a less conventional way, also that the drainage of IVC through the maintenance of a negative pressure along the injured IVC wall could have a positive effect in stopping the bleeding. The choice of such kind of stent was very important, because the endovascular treatment of a large and short zone can pose problem. Normally, the CP stent is recommended to treat congenital aortic coarctaction, but it provides a wide range of diameters and lengths to treat the large vessel, so we decided to use this kind of covered stent because it allows exclusion of the lesion, leaving permeable hepatic veins and place for a venous cannula.

CONCLUSION

This study describes the successful use and feasibility, in a multi-trauma patient, of SG to treat intra-abdominal uncontrolled haemorrhage from a traumatic injury of the IVC, combined with the use of ECMO for a refractory hypoxia secondary to severe pulmonary contusion. Moreover, we think that the position of the ECMO cannula along the injured IVC in order to maintain a negative pressure could help to decrease the bleeding.

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REFERENCES