Editorial

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ECMO in Trauma Patients Requiring Total Pulmonectomy: Could This be a New Approach in the Era of Hybrid Management?

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Most traumatic chest injuries can be safely managed conservatively by chest thoracotomy and respiratory support. Only 10–20% of chest injuries require surgery, mostly due to haemodynamic instability and/or a massive uncontrolled air leak [1]. In the vast majority of cases undergoing surgery, the haemostasis or leak control may be achieved by relatively simple lung sparing techniques such as suturing, tractotomy or non-anatomical wedge resection [2]. The real need for formal lung resection remains unclear, accounting for 10–30% of operative cases [3,4]. In a study on 143 chest trauma patients undergoing surgery, Karmy-Jones et al. demonstrated that each step that increases the complexity of the surgical technique and the volume of resected lung tissue is an independent risk factor for mortality [5]. Aiolfi et al. reported similar results in their recent large study on 3,107 patients [6].

In very rare cases of massive bronchial leak or bleeding from the region of the pulmonary root, closure of the lung hilum is mandatory. Temporary vascular clamping or lung twisting may achieve temporary control. In these cases, total pneumonectomy is considered a last resort due to the associated mortality rates that reach 75–100% in most series [7,8]. The main reasons for a patient's death are uncontrolled bleeding, appearance of the death triad and the rapid development of fulminant right heart failure unresponsive to medical therapy [9]. Although the right heart is still functioning after a pneumonectomy, the thin-walled structure is unable to pump effectively against rapid pressure increases, resulting from redistribution of pulmonary bed circulation after closure of one of the pulmonary hilums [10]. In most extremely unstable patients requiring total pulmonectomy, the patient is probably unsalvageable. However, in some cases patients undergo explorative thoracotomy due to massive haemothorax or persistent ongoing bleeding while initial physiologic parameters are still relatively stable. Under such circumstances, deterioration after chest opening and exploration is expected. In these select patients, we believe that veno-arterial Extracorporeal Membrane Oxygenation (ECMO) may be a promising solution for this currently unresolved problem.

ECMO is a form of cardiopulmonary life-support, first described in the 1970s. For many years, ECMO has been indicated for supportive therapy of severe cardiopulmonary disease in patients unresponsive to medical treatment for hypoxemic respiratory failure, mainly resulting from Acute Respiratory Distress Syndrome (ARDS) and lung contusion [11]. In a large randomized controlled study on 188 adults with severe acute respiratory failure, Peek et al. demonstrated that treatment with ECMO was associated with significantly reduced mortality rates compared with conventional protocols [12]. Since the publication of this study, ECMO gained popularity, with physicians worldwide accumulating wide experience using this method of treatment. ECMO is usually used in one of the two following ways: the veno-venous (VV) configuration when the blood is drained and replaced in the venous system, or alternatively, the veno-arterial (VA) configuration when the blood is drained from the venous system and returned to the arterial system providing both respiratory and cardiac support [13]. Indications for ECMO include cardiac support (VA ECMO), respiratory support (VV ECMO) or a combination of both (VA ECMO).

Little is known about the feasibility of ECMO in acute trauma settings. Some studies describe the use of ECMO for ARDS or lung contusion in severely injuries trauma patients [14,15]. The major concern about ECMO use in trauma is the estimated risk of bleeding

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complications due to use of anticoagulation. However, in a study on 52 trauma patients, Kruit et al. have shown that ECMO in trauma patients does not exacerbate the primary traumatic injury, regardless of anticoagulation initiation. Nevertheless, in their study, initiation of ECMO treatment was performed on average 3 days after the initial therapeutic procedures [16].

In this editorial, we discuss the feasibility of ECMO use in patients in whom the single option for bleeding control is pulmonectomy. In our proposed protocol, ECMO placement will be done as soon as possible and anticoagulation strategy should be adapted accordingly. Therefore, we propose using a minimizing heparin dose strategy described by Wu et al. This approach avoids pre-cannulation heparin dose and provides continuous maintenance dose of heparin after 48 hours of ECMO when a near-normal activated partial thromboplastin time (<40 s) is the therapeutic goal [17].

Peripheral percutaneous ultrasound-guided VA cannulation is the preferred technique for cannulation of the femoral artery and vein using a modified Seldinger technique. This method is associated with lower bleeding and infection rates, compared with open surgical techniques. However, these claims are not based on studies that involve severely hypovolemic patients, with concomitant venous congestion due to RV congestion/failure and arterial vasoconstriction due to hypovolemia. Such conditions might severely impair the ability for ultrasound-guided access.

After ultrasound identification of both vessels, vascular access is gained, avoiding a lateral or back wall puncture. Subsequently, the wire is advanced to the abdominal aorta and the cannula (15–19 Fr) is inserted. The venous drainage is achieved by the cannula (23–25 Fr) in the femoral vein with the tip positioned at the level of the right atrium. The preferred way for the confirmation of guidewire route is fluoroscopy. Transthoracic echocardiography alone is insufficient to avoid vessel injury or dislocation because it cannot identify kinking of the guidewire during the dilation or insertion of the cannula. In addition, the pitfalls of cannulation include vascular complications or ischaemia of the corresponding extremity, blood loss and/or relocation of cannulas, hypoxia of the upper body [18]. Deoxygenated blood will be drained at the right atrium and oxygenated blood will be returned retrogradely into the aorta. [19,20]. In this way, peripheral VA-ECMO configuration will partially (up to 90%) bypass the pulmonary vascular bed. This bypass will potentially 'buy time' that will enable the addressing of the bleeding as well as enable the right ventricle to adapt to the pulmonectomy.

The main advantage of peripheral VA-ECMO is the relative simplicity and speed of initiation of ECMO. For example, Yannopoulos et al. reported a mean initiation time of 6.3+2 min [21]. Routine use of a distal cannula is also recommended after control of the thoracic bleeding to minimize the risk of distal limb ischaemia. This may be performed by accessing the superficial femoral artery with an antegrade needle access, using a 5–6 Fr sheath [22].

The evidence mentioned above supports the feasibility of ECMO use in acute trauma patients. In our opinion, VA-ECMO may potentially improve outcomes in trauma victims previously considered unsalvageable. This concept requires the immediate availability of both ECMO equipment and properly trained staff. In addition, awareness of the trauma surgeon is necessary to allow early use of ECMO in trauma victims. Possible methods that may enable initiating ECMO before total pulmonectomy include intermittent lung twisting, alternating lung hilum clamping and use of balloon technique for temporary proximal and distal control. Despite the technical evolution and today's improved protocols, current data regarding ECMO use is mainly based on observational and mostly retrospective studies. It should be highlighted that there is no data regarding the efficacy of ECMO use before, during or after surgery. The question whether ECMO should always precede pulmonectomy remains unanswered. Therefore, the proper timing of initiation of ECMO is controversial and an adequate strategy should be developed in the future. We believe that animal studies followed by prospective controlled trials are urgently needed in order to generate evidence on safety and efficacy of ECMO support in acute trauma settings.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no financial support for this work.

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