Cardiopulmonary Bypass and Extracorporeal Life Support for Emergent Intraoperative Thoracic Situations

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KEYWORDS

• Cardiopulmonary bypass • Extracorporeal life support • Extracorporeal membrane oxygenation • Lung cancer • Lung transplantation

KEY POINTS

- Initiation of extracorporeal life support during intraoperative thoracic surgical catastrophes can be lifesaving.
- Detailed knowledge of the different modes of support available can aid surgeons in decision making for identifying the ideal mode required for each scenario.
- Clear communication and effective team coordination are crucial.

INTRODUCTION

The availability of cardiopulmonary bypass (CPB) or extracorporeal life support (ECLS) (also referred to as extracorporeal membrane oxygenation [ECMO]) to support a patient during an intraoperative thoracic surgical crisis can be lifesaving. Common causes of intraoperative cardiac arrest, such as hemorrhagic shock and hypoxia, can be managed with either CPB or ECMO, depending on the degree of support required for different levels of complexity. With increasing applications of ECLS in thoracic surgery (such as in bridge to lung transplant, intraoperative lung transplant support, and bridge to recovery after lung transplantation), being knowledgeable about the capabilities and differences between CPB, venoarterial (VA) ECMO, and venovenous (VV) ECMO can guide rapid intraoperative decisions under stressful conditions and greatly benefit patients (Fig. 1).

After a brief review of predictors of intraoperative mortality in noncardiac surgery, this article addresses potential applications and the reported clinical experience with CPB, VA-ECMO, and VV-ECMO in thoracic surgical procedures.

PREDICTORS OF OPERATIVE MORTALITY AND AVOIDABLE FACTORS

Intraoperative cardiac arrest poses a unique situation. The patient is fully monitored and the medical team is readily available to react to the causative factor. In the past, intraoperative cardiac arrest was divided into anesthesia related, surgery related, or related to patient characteristics and reason for surgery.[1] Among the anesthesia-related causes, airway issues and medication

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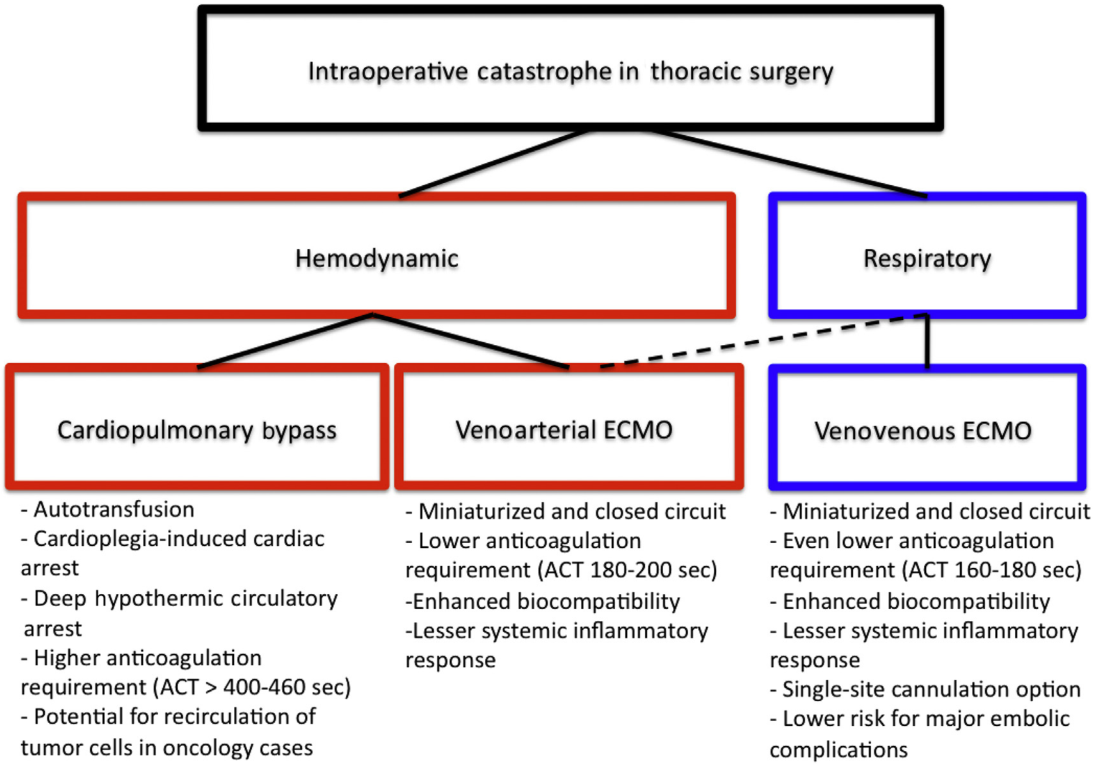

Fig. 1. Features of different modes of support for thoracic surgery intraoperative catastrophes. ACT, activated clotting time.

side effects are commonly associated with arrest. Among the surgical factors, bleeding is often highlighted. In a large study comprising 518,294 patients, with 223 intraoperative arrests, factor such as high American Society of Anesthesiologists (ASA) score, general anesthesia, emergent procedures, use of vasopressors before arrest, protracted hypotension before arrest, bleeding as the cause of arrest, and arrest during nonstandard working hours were all associated with worse survival after resuscitative measures.[2] However, on a multivariate analysis, only bleeding, documented hypotension, nonstandard working hours, and diabetes proved to be independent predictors of survival. Although 34.5% of patients experiencing intraoperative arrest survived to hospital discharge, these numbers decreased to 10.3% when the arrest was attributed to bleeding.

In a more recent multicenter study from the American College of Surgeons National Surgical Quality Improvement Program database (362,767 patients; 0.072% intraoperative arrest with a 62% 30-day mortality), Goswami and colleagues[3] showed that, among factors such as emergent surgery, ASA score, and preoperative comorbidities, intraoperative blood transfusion was the most striking factor associated with intraoperative cardiac arrest. More importantly, there was a dose-dependent correlation with intraoperative arrest, with adjusted odds ratios of 2.5 (95% confidence interval [CI], 1.69–3.71), 7.59 (95% CI, 4.94–11.67), 11.4 (95% CI, 6.22–20.88), and 29.68 (95% CI, 18.66–47.18) if the patient required 1 to 3, 4 to 6, 7 to 9, or greater than or equal to 10 units of packed red blood cells, respectively.

Focusing on patients who experienced intraoperative cardiac arrest but were successfully resuscitated and made it to intensive care unit (ICU) recovery (total 140, with 20.7% thoracic surgery patients), Constant and colleagues[1] showed a 45.7% ICU mortality, mostly caused by multiple organ failure. In contrast, 45.3% of patients were alive at 90-day follow-up with either good cerebral function or enough function to perform daily activities. Independent predictors of favorable neurologic outcome were ventricular fibrillation/tachycardia as the first recorded rhythm and no use of epinephrine to treat postarrest shock (reflecting the severity of shock). A similar large multicenter study has also reinforced the correlation of ventricular fibrillation/tachycardia as the primary arrest rhythm and improved outcomes.[4]