

a high risk of pulmonary injury. However, these techniques reduce surgical clarity and usually allow only rapid and relatively easy procedures (talc, biopsy, and wedge resection).

As an alternative to the above options, the use of cardiopulmonary bypass, extracorporeal CO₂ removal (ECCO2R), or ECMO (VV for lung resection only, VA for surgery involving both the heart and large vessels) can be considered. High doses of anticoagulation are required for cardiopulmonary bypass, and its use may not extend beyond the operating room. ECCO2R is good for carbon dioxide elimination, but oxygenation is poor, and therefore some combination with (ultraprotective) ventilation is necessary. ECMO, on the other hand, does not have these limitations, can be managed without anticoagulation, provides an excellent gas exchange, and its use can be extended for the postoperative period. We have exclusively used the VV ECMO in our cases.

The use of VV ECMO has been described in cases of tracheobronchial tree resection, carina resection, sleeve lobectomies [5–7], tracheobronchial tree injury [8, 9], and cases of large mediastinal tumors causing tracheal compression [10]. Moreover, VV ECMO has been used to support a wide range of procedures where reduced pulmonary

reserve makes one-lung ventilation impossible or unsafe. Oey et al. [11] described the resection of an emphysematous bulla after a previous pneumonectomy. Tsunazuka et al. reported resection of bullae in the sense of lung volume reduction surgery (LVRS) in severe emphysema [12]. VV ECMO has also been used during lung resection surgery following previous resections, such as lobectomies and pneumonectomies on the contralateral lung [13].

Several authors have described the use of VV ECMO in ARDS patients who underwent limited lung resections for aspergillosis or lung abscess [14, 15], persistent massive air leak [16], or lung necrosis [17].

Conclusion

Patients in whom selective intubation and/or ventilation is not possible but who require surgery may benefit from VV ECMO. Morbidity and mortality rates in carefully selected patients for VV ECMO-assisted elective lung resection surgery are very low. Patients with respiratory failure requiring surgical treatment may also benefit from VV ECMO. In this case, morbidity and post-operative mortality are high, but related to the underlying disease.

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