Elective extra corporeal membrane oxygenation for high-risk rigid bronchoscopy

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ABSTRACT

The use of extracorporeal membrane oxygenation for high-risk rigid bronchoscopy has been reported in few urgent cases. We report our experience with this approach which was planned electively in five cases on 202 procedures (2.5%). It was proposed because of the potential inability to ventilate the lungs using conventional techniques due to extensive tracheobronchial lesions or the risk of major intraoperative bleeding related to disease characteristics. There were no intraoperative complications and postoperative course was favourable in all patients. With a maximum follow-up of 3 years and 7 months, all patients are alive with no tracheostomy despite major morbidities.

INTRODUCTION

Rigid bronchoscopy (RB) remains one of the most important techniques in the management of central airway diseases. Controlled and jet ventilation are routinely used during RB. This can be challenging, especially in case of respiratory failure and/or severe haemorrhage.[1] The use of extracorporeal membrane oxygenation (ECMO) has been reported in airway surgery and more rarely for urgent bronchoscopies.[2–4] We present here our experience with elective Veno-Venous (VV) ECMO for high-risk RB.

METHOD

From January 2016 to December 2019, 202 rigid bronchoscopies have been performed in patients referred to our 24/7 Airway Diseases Center for malignant or benign lesions. A major risk of massive bleeding or respiratory failure was identified in five cases (2.5%). There were four female and one male patients with a mean age of 45.8 years (ranging from 20 to 67 years). Patient characteristics including medical history, type of diseases and previous treatment are presented in table 1. All patients except one were referred from other medical centres. Two of them were discussed for a tracheal transplantation according to our prospective feasibility study evaluating the use of stented aortic matrices but were finally excluded because of comorbidities and/or general status.[5] All patients had a preoperative venous ultrasound and echocardiography. All case files were validated by our tracheobronchial diseases multidisciplinary team meeting. Enrolment criteria were the potential inability to ventilate the lungs using conventional techniques with respiratory failure because of (1) extensive tracheobronchial lesions (patients 1, 4, 5) or (b) the risk of major intraoperative bleeding related to disease characteristics (patients 2, 3). VV ECMO indications of elective respiratory support during RB are detailed for each patient in table 1 and figure 1. Contraindications to VV ECMO were disseminated malignancy, severe chronic organ dysfunction and major chronic pulmonary hypertension (>50 mm Hg). All patients provided written informed consent for RB and VV ECMO. The operation consisted of RB under elective VV ECMO (figure 2). Cannulation was performed under sedation and local anaesthetics infiltration of the cannula sites in patients 1 and 5 (n=2). Sedation was obtained by small boluses of midazolam and a target controlled infusion (TCI) of remifentanil. In patients 2, 3 and 4 (n=3), general anaesthesia was initiated before cannulation using propofol/remifentanil TCI. Patients were intubated (rocuronium) and conventional ventilation was performed (5–7 mL/kg tidal volume, respiratory rate 10–12/min and fractional inspired oxygen <60%) prior to bronchoscopy. After an intravenous bolus of heparin (5000 IU), percutaneous cannulation with ultrasound guidance was performed using a 25–29 Fr inflow cannula in the femoral vein and a 21 Fr return cannula in the right jugular vein. Both cannulas were connected to a heparin-coated circuit (Quadrox HLS, Maquet) with a centrifugal pump (Cardiohelp, Maquet) providing a flow from 60% to 90% of the theoretical cardiac output. Once VV ECMO was in place for patients 1 and 2, the depth of anaesthesia was increased using propofol/remifentanil TCI. Finally, rocuronium was administered prior to RB. Patients 2, 3 and 4 were extubated prior to RB. No other heparin boluses or infusions were administered during the procedure.

RESULTS

Characteristics related to the procedure, postoperative course and long-term follow-up are detailed in table 1. The duration of the procedure ranged from 80 to 130 min. The additional time to place the patient under ECMO was estimated at 15–50 min. In all patients, ECMO was well tolerated during the procedure. It was not necessary to ventilate the lungs because oxygen saturation of the haemoglobin measured with digital pulse oximetry was superior to 98%. Management of hypotension (systolic pressure inferior to 90 mm Hg) required repeated boluses of vasopressors. In patient 2, haemodynamic instability due to tumour bleeding needed continuous infusion of vasopressors. There was no intraoperative complication related to the use of ECMO. In summary, different

Table 1 Characteristics related to the medical history, the type of diseases, the previous treatment, the procedure, the postoperative course and the long-term follow-up

	Sex, age (years)	Medical history	Type of diseases and previous treatment	ECMO enrolment criteria	Operation date	Procedure	ECMO duration	Postoperative follow-up	Maximal follow-up	Current status
1	M, 67	Past smoker Tuberculosis Epilepsy Esophagectomy for cancer Left vocal cord paralysis	Cancer recurrence Total esophagectomy Per-operative laceration of the entire trachea Mediastinitis	Respiratory failure	May 2016	Extended Y stenting Tracheotomy	1.5 hours	Uneventful Tracheotomy removal 1 year Stent removal 1 year 4 months	3 years, 7 months	Alive No cancer recurrence No tracheotomy No stent
2	F, 25	Chronic cough	Typical carcinoid tumour Right main stem bronchus obstruction Right lung atelectasis Preoperative embolisation	Massive bleeding Respiratory failure	October 2016	Massive bleeding Incomplete bronchoscopic tumour removal Stent Tracheotomy	22 days	Pneumothorax Pneumonia Tracheotomy removal 2 months Stent removal 4 months	3 years, 2 months	Alive Medical treatment (mTOR inhibitor) Pneumonectomy No tracheotomy No stent
3	F, 57	Past smoker Asthma Breast cancer: Surgical resection +Chemoradiation Tracheal adenoid cystic carcinoma (ACC): endoscopic resection	Recurrent ACC: carinal resection (January 2016) ARDS Left main stem bronchus stenting Long-term mediastinal stent migration	Massive bleeding Respiratory failure	October 2017	Minor bleeding Stent removal Placement of a new stent in the left main stem bronchus	1.5 hours	Uneventful Chronic colonisation by pseudomonas aeruginosa Asthma attacks	2 years, 2 months	Alive No recurrence of ACC No tracheotomy One stent in place
4	F, 60	Past smoker Morbid obesity Hypertension Gastro-oesophageal reflux disease Pulmonary embolism (×3), sleep apnoea appendicectomy bowel obstruction, Hysterectomy Ovariectomy	Excessive dynamic airway collapse (EDAC): surgical treatment 2004 Multiple rigid bronchoscopies since 2008: stent placement and removal, granulation tissue removal	Respiratory failure	October 2017	Extended Y stenting Tracheotomy	2 hours	Uneventful Acute bronchitis Tracheotomy Removal 8 months Tracheoplasty 1 year 4 months	2 years, 2 months	Alive No tracheotomy One stent in place
5	F, 20	Undetermined inflammatory tracheobronchial disease Recurrent pneumonia and respiratory failure Corticosteroid-induced osteoporosis Cachexia	Multiple tracheal and bronchial stenoses Medical treatment FEV_1=340 mL (11.4%) Residual lumen of the trachea=3–4 mm	Respiratory failure	April 2019	Tracheal dilatation (×2) and stenting Bronchial dilatation	24 hours	Uneventful Stent obstruction Stenosis recurrence Stent removal and new Y stenting under VV ECMO	8 months	Alive No tracheotomy One stent in place

ARDS, acute respiratory distress syndrome; ECMO, extra corporeal membrane oxygenation; FEV_1, forced expiratory volume in one second; VV, veno-venous.

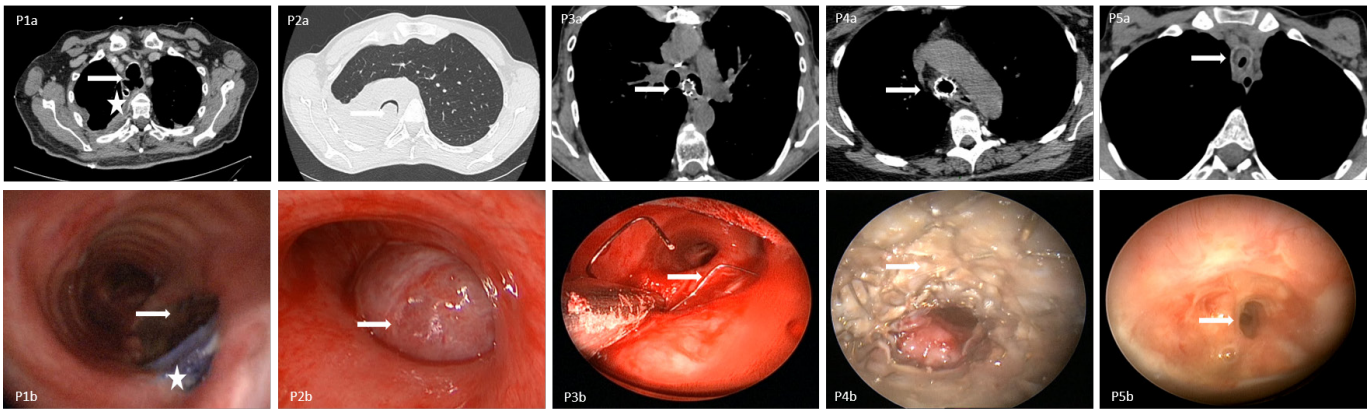

Figure 1 Transversal view of chest CT scan (a) and a bronchoscopic image (b) for each patient. Patient 1 (P1) had a peroperative laceration of the entire trachea (arrow) during total esophagectomy. The chest tube (star) was visible through the tracheal lumen. There was a potential inability to ventilate the lungs using conventional techniques with a major risk of respiratory failure at bronchoscopic Y stenting. Patient 2 (P2) had a huge typical carcinoid tumour (arrow) with a right main stem bronchus obstruction leading to lung atelectasis. A major bleeding was observed at biopsies under flexible bronchoscopy. A risk of massive bleeding with respiratory failure was identified for tumour removal using RB. Patient 3 (P3) had a mediastinal stent migration (arrow) at long-term follow-up after carinal resection and stenting. A risk of massive bleeding with respiratory failure was established for stent removal under RB. Patient 4 (P4) had multiple endoscopic stenting for a severe excessive dynamic airway collapse. Major stent complications (arrow) occurred due to stenosis, obstructive granulation tissue, migration, fracture and infection. There were major risks associated with stent removal, these including mucosal tears, severe bleeding, re-obstruction and respiratory failure. Patient 5 (P5) had multiple tracheal and bronchial stenoses with a residual trachea measuring 3–4 mm (arrow). A potential risk of respiratory failure using conventional or jet ventilation was found. RB, rigid bronchoscopy.

procedures were performed, including extended Y stenting for airway reconstruction (n=2); incomplete bronchoscopic tumour removal and stenting (n=1); stent replacement (n=1) and tracheobronchial dilatation followed by stenting (n=1). In three patients, a temporary tracheostomy was used. In three patients, the VV ECMO was removed at the end of the procedure (time <2 hours) and postoperative course was uneventful. In two patients, it was prolonged because of respiratory failure for 22 days or 24 hours, respectively in patients 2 and 5. For all patients, the last follow-up visit occurred on 18 December 2019. With a maximum follow-up of 3 years and 7 months, all patients are alive with no tracheostomy. Three patients have a tracheal stent in place. One patient required a new dilatation with stent placement under VV ECMO. No long-term complications have been associated with the use of VV ECMO in this series.

DISCUSSION

Our preliminary experience showed that VV ECMO was well tolerated in patients requiring an RB at risk of respiratory failure and/or bleeding. With a maximum long-term follow-up of 3 years and 7 months, complications were mainly associated with underlying diseases. We believe that the use of VV ECMO have significantly impacted the ability to complete the procedure because ventilation would probably have been impossible to maintain due to major tracheal lesions in patients 1, 4, 5 or to massive bleeding in patient 2. On the other hand, the procedure might have been performed without VV ECMO only in patient 3 since there was no massive bleeding. Thus, the VV ECMO could have been on stand-by for this last patient. This could be an option for similar cases in the future. In the majority of patients, VV ECMO was used only during the procedure; there were no intraoperative complications; postoperative course was uneventful and long-term follow-up was satisfactory despite severe tracheobronchial diseases and comorbidities. Hypotension was observed in all patients and was successfully managed by the use of vasopressors. In patient 2, we believe that bleeding was related to the carcinoid tumour more than heparinisation because it had also been observed in previous biopsies. On the other hand, the use of heparin did not cause any bleeding in patient 3. As ECMO duration was relatively short (except for

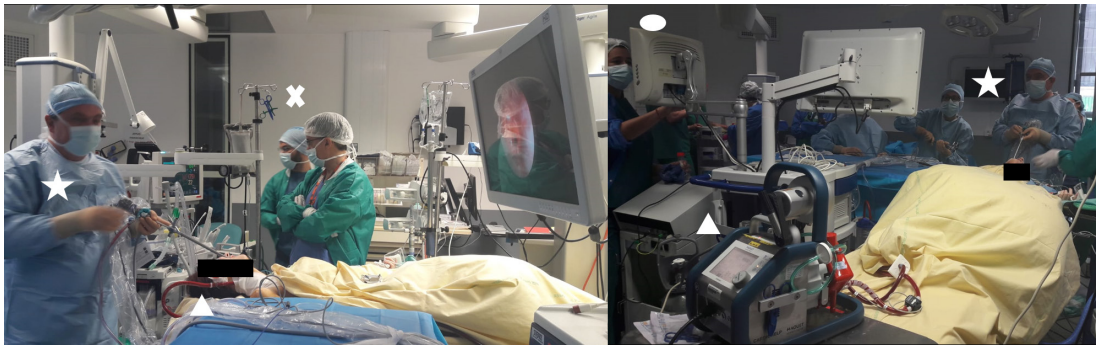

Figure 2 Anonymised patient who had a rigid bronchoscopy by our surgical team (white star) under general anaesthesia and elective veno-venous extra corporeal membrane oxygenation (white triangle) in collaboration with the anaesthesiologist team (white cross) and operating theatre nurses (white circle).

patient 2), we did not observe complications usually associated with this technique like bleeding, deep venous thrombosis/pulmonary embolism, pneumothorax, infections and mechanical problems. Long-term events were only related to underlying airway diseases. Future prospective studies could compare two groups of patients having ECMO or not during a high-risk RB and evaluate intraoperative parameters and complications. ECMO indications for respiratory support in adult patients are Acute Respiratory Distress Syndrome, airway obstruction, pulmonary contusion, smoke inhalation, primary graft failure after lung transplantation, bridge to lung transplant, lung hyperinflation and pulmonary haemorrhage.[6] In 2009, Chen reported his successful experience with emergency VV ECMO support in a patient who had tracheal obstruction during RB for stent removal.[4] George and colleagues used the same procedure for stent removal and placement in a patient with severe tracheobronchomalacia.[7] In the same way, Zhu and colleagues proposed VV ECMO support as an alternative to conventional or jet ventilation in patients with severe tracheal stenosis undergoing urgent tracheal stenting.[8] The overall mortality rate associated with RB was less than 1% in the most important series.[1] In addition, mortality is usually linked to respiratory failure and/or severe haemorrhage. Consequently, Gourdin and colleagues planned VV ECMO support before the administration of general anaesthesia to prevent oxygenation failure during RB in a patient who required a high-risk stent removal.[9] Dunkman and colleagues reported in a 37-year-old patient the elective use of VV ECMO for the resection of a carinal schwannoma with no recurrence after 6 months of follow-up.[10] Finally, Hong and colleagues published a case series of VV ECMO used as a bridge to support interventions for severe airway obstruction.[11] The main limitation of this last study was the short follow-up time of only 2 months. Modern ventilation strategies now allow oxygenation in the majority of patients who have an RB. Nevertheless, RB is still contraindicated in case of a high risk of failure to ventilate, either due to obstruction or bleeding. This problem can be avoided with the use of VV ECMO. The present study confirmed that elective VV ECMO was well tolerated during high-risk RB. Indeed, short-time VV ECMO is safe, can be deployed easily and has the potential to turn high-risk RB into routine procedures. As a result, elective VV ECMO could be used more widely during RB, especially when the procedure is contraindicated because a high risk of respiratory failure and/or bleeding. We believe that there are no obstacles today to the development of this emerging approach. Further studies are needed to confirm our preliminary results.

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