SUCCESSFUL MANAGEMENT OF UNILATERAL RE-EXPANSION PULMONARY EDEMA FOLLOWING ONE-LUNG VENTILATION FOR ROBOT-ASSISTED MITRAL VALVE REPAIR: A CASE REPORT

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Abstract

Within the past decade, a few cases of re-expansion pulmonary edema have been reported after one-lung ventilation for minimally invasive cardiac surgery. This complication is severe and may result in mortality, despite aggressive treatment. In the present case, a 46-year-old man with mitral valve regurgitation was scheduled for robot-assisted mitral valve repair with one-lung ventilation. However, unilateral pulmonary edema was observed immediately after re-expansion of the right-sided collapsed lung. Pulmonary edema was improved after ventilator support, extracorporeal membrane oxygenation, and bronchoscope-assisted secretion clearance. The patient was extubated and discharged without any sequelae. In this case, risk factors contributing to pulmonary edema included a history of congestive heart failure with pulmonary edema, undergoing mitral valve repair, longer cardiopulmonary bypass and cross-clamp times, transfusion of fresh frozen plasma during the operation, and a relatively high mean pulmonary pressure. For anesthesiologists, awareness of major risk factors, peri-operative respiratory strategy and protection, early clinical recognition, cardiovascular stability, and improvement of supportive treatment may reduce the incidence and mortality rate of re-expansion pulmonary edema during robot-assisted mitral valve surgery under one-lung ventilation.

Key Words: Extracorporeal membrane oxygenation, mitral valve repair, one-lung ventilation, pulmonary edema, robot-assisted surgery

Introduction

Robot-assisted mitral valve repair has become increasingly popular in recent years because this method is associated with reduced frequency of re-operation due to bleeding and shorter stays in the intensive care unit and hospital; however, longer cardiopulmonary bypass (CPB) and aortic cross-clamp times have also been noted. A cohort study of 300 robot-assisted mitral valve repairs showed the safety and effectiveness of this method, with a low incidence of major adverse events. However, the risk of re-expansion pulmonary edema remains a concern for anesthesiologists.
cardiac events.\textsuperscript{4} Robot-assisted cardiac surgery usually requires one-lung ventilation (OLV). Pulmonary and systemic inflammatory responses are produced by re-expansion after OLV and may further cause cardiopulmonary stress and related complications.\textsuperscript{5}

Unilateral re-expansion pulmonary edema is a rare but potentially lethal peri-operative complication and may be caused by rapid re-inflation of the collapsed lung after OLV. A few cases of this complication have been reported following minimally invasive cardiac surgery.\textsuperscript{6-8} Here, we present the first report of a case of unilateral re-expansion pulmonary edema following OLV for robot-assisted mitral valve repair.

\section*{Case Report}

A 46-year-old man (168 cm, 82 kg) suffered from hypertension and congestive heart failure related to mitral regurgitation, diagnosed 6 years prior. Due to progressive dyspnea on exertion for several months with mitral regurgitation progression, he was admitted for robot-assisted mitral valve repair. Pre-operative transesophageal echocardiography (TEE) revealed severe mitral regurgitation with P3 chordal rupture and mild systolic dysfunction. Pre-operative chest roentography showed no active lung lesions (Fig. 1). General anesthesia was carried out with fentanyl and propofol and maintained with sevoflurane. Cisatracurium was also used to facilitate a 35F left-sided double-lumen endotracheal tube intubation. Except for regular monitoring with ECG, SpO\textsubscript{2}, and a blood pressure monitor, we also maintained a radial arterial catheter, central venous catheter, pulmonary arterial catheter, and TEE monitor. Robot-assisted mitral valve repair and mitral annuloplasty were performed smoothly with peripheral cardiopulmonary bypass (CPB), transthoracic aortic cross-clamp, and antegrade cardioplegia. Myocardial protection was provided by systemic hypothermia (28°C) and cardioplegia infusion. The duration of operation was 9.5 h, with 405 min of CPB, 215 min of aortic cross-clamp, and 3 h of left-side OLV before and after CPB. TEE revealed minimal residual mitral regurgitation and unchanged left ventricular systolic function compared with the pre-operative condition. While returning to two-lung ventilation after weaning from CPB, hypoxemia with low PaO\textsubscript{2}/FiO\textsubscript{2} ratio (73.6) and serous yellowish sputum were noted immediately. Elevating the FiO\textsubscript{2} to 1.0 and PEEP to 10 mmHg only slightly improved arterial oxygenation, and the PaO\textsubscript{2} remained below 80 mmHg.

The patient was sent to the intensive care unit with inotropic agent infusion of dopamine, epinephrine, and norepinephrine. Post-operative chest roentography showed diffuse, dense opacification on the right lung field, consistent with severe right-sided pulmonary edema (Fig. 2). Elevated mean pulmonary artery pressure of about 40 mmHg was also noted. Venovenous extracorporeal membrane oxygenation (ECMO) was established on the first post-operative day for persistent hypoxemia, and continuous venovenous hemofiltration (CVVH) was started the same day due to pulmonary edema and progressive oliguria. Bronchoscopic examination was carried out on day 3 because of the lack of improvement of arterial
Blood clots and sputum impaction were found and removed, after which, significant improvement of arterial oxygenation was observed. ECMO and CVVH were removed on the fourth postoperative day, with tracheal extubated on the seventh postoperative day. The patient was discharged on the 17th postoperative day after clearing of the right-sided pulmonary edema.

Discussion

In this case report, we describe the first case of re-expansion pulmonary edema after OLV for robot-assisted mitral valve repair. Despite the severity of the complication, the patient recovered within 17 days post-operation and was discharged.

Re-expansion pulmonary edema after OLV for mitral valve repair is thought to be caused by increasing pulmonary capillary permeability, and ischemia-reperfusion injury is a significant contributing factor. In the present case, re-expansion pulmonary edema with severe hypoxemia was noticed when initiating two-lung ventilation after weaning from CPB. Ischemia-reperfusion injury with systemic inflammation reaction after OLV and CPB was considered the main cause.

The first case of unilateral re-expansion pulmonary edema after OLV for minimally invasive mitral valve surgery was described in 2009.\(^7\) One report showed that there is a 7.9% incidence of radiographically evident unilateral pulmonary edema after minimally invasive cardiac surgery (MICS) with intra-operative collapse of a lung.\(^7\) Diabetes mellitus, the level of mean pulmonary pressure, and transfusion of fresh frozen plasma may contribute to unilateral pulmonary edema after MICS. Additionally, in a recent case-control study,\(^8\) undergoing mitral valve repair or replacement, right ventricular dysfunction, pulmonary hypertension, and longer CPB and cross-clamp times were found to be risk factors of unilateral post-operative pulmonary edema after MICS. The authors showed that the incidence of unilateral post-operative pulmonary edema was 25%. Moreover, the mortality rate was high, the post-operative PaO\(_2\)/FiO\(_2\) ratio was low, and vasoactive medications, mechanical ventilation for longer than 24 h, and longer intensive care unit and hospital stays were required. In the present case, our patient had several risk factors, including history of congestive heart failure with pulmonary edema, undergoing mitral valve repair, longer CPB and cross-clamp times, transfusion of fresh frozen plasma during operation, and relatively high mean pulmonary pressure, which may have contributed to re-expansion pulmonary edema.

Understanding these predicting factors will allow surgeons and anesthesiologists to take extra precautions with high-risk patients. Therefore, during and after surgery involving OLV, we should eliminate as many known risk factors for post-operative lung injury as possible, including unnecessary hyperoxia, lung overinflation, fluid overload, and lung collapse. This can be achieved by reducing inspiratory oxygen fraction, reducing tidal volume, applying PEEP and lung recruitment maneuvers to the ventilated lungs, and applying CPAP to the collapsed lungs.\(^1\)

The treatment of re-expansion pulmonary edema mainly is conventional supportive
therapy. In this case, ECMO, diuretic therapy with CVVH, and prolonged ventilator support with PEEP were involved. Other strategies include lateral position with the edema side up or differential lung ventilation at the initial phase of pulmonary edema. A single dose of dexamethasone administered after anesthesia induction (approximately 1 mg/kg body weight) significantly reduces the incidence of unilateral pulmonary edema after MICS. In our case, 10 mg of dexamethasone was given intravenously after anesthesia induction; this was a relatively low dosage, and therefore, we will consider increasing the dosage of dexamethasone to 1 mg/kg body weight after anesthesia induction.

The incidence of unilateral pulmonary edema ranges from 8% to 25% after MICS. In robot-assisted mitral valve repair surgery with OLV, the incidence of re-expansion pulmonary edema may increase due to prolonged CPB time, prolonged aortic cross-clamp time, and ischemia-reperfusion injury after OLV. Clinicians at the Mayo Clinic reported 200 cases of robotic mitral repair, revealing statistically significant decreases in operative times, CPB times, and aortic cross-clamp times. Therefore, improvement of operative techniques and equipment with increasing surgical experience may lower the incidence of pulmonary edema in high-risk patients in the future.

In summary, patients with unilateral re-expansion pulmonary edema after OLV have a higher risk of mortality. For anesthesiologists, awareness of major risk factors, peri-operative respiratory strategy and protection, early clinical recognition, cardiovascular stability, and improvement of supportive treatment may reduce the incidence and mortality rate of re-expansion pulmonary edema during robot-assisted mitral valve surgery under OLV.

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References

機械手臂輔助二尖瓣膜修補手術之單肺通氣後
單側再擴張肺水腫之成功處理：─病例報告

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摘要

根據文獻紀錄，在過去十年之中進行微創心臟手術的病人，有數起病例併發單
肺通氣後的單側再擴張性肺水腫。此類嚴重併發症，即使在積極的介入性治療
下，仍有可能造成病人死亡。本案例報告是一位 46 歲男性，診斷為二尖瓣逆流。
此病例為文獻紀錄中，首位進行機械手臂輔助二尖瓣膜修補手術後，併發單肺通
氣後的單側再擴張性肺水腫之案例。經過呼吸器和體外膜氧合器的系統性支持、
以及支氣管鏡協助移除呼吸道分泌物，肺水腫明顯改善。病人最後順利移除氣管
內管，在沒有任何後遺症下出院。根據近期研究報告，在在此病例中，有數個可能
造成再擴張性肺水腫的危險因子，包括：病人有鬱血性心臟衰竭合併肺水腫之病
史、施行二尖瓣膜修補手術、較長時間的體外心肺循環以及主動脈橫斷鉗閉術、
手術中輸注新鮮冷凍血漿、以及肺高壓。對於麻醉科醫師，針對機械手臂輔助二
尖瓣膜手術合併單肺通氣之病患，辨識出高風險族群、圍術期間呼吸器設定以及
呼吸系統保護措施、及早發現相關臨床徵象、穩定心血管系統、以及改善各系統
支持治療方式，將有助於減少再擴張性肺水腫的發生率和死亡率。

關鍵詞：肺水腫，機械手臂輔助手術，二尖瓣膜修補，單肺通氣，體外膜氧合器

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