Extracorporeal membrane oxygenation for the control of a pulmonary artery hemorrhage

Yuichiro Hirata[1], Eiki Tayama[2], Ryuya Nomura[2], Tomofumi Fukuda[2], Kojiro Furukawa[2], Tatshushi Onzuka[2], and Shigeki Morita[3]

[1]Kyusyu Medical Center, National Hospital Organization
[2]Affiliation not available
[3]National Hospital Organaization Kyushu Medical Center

June 9, 2021

Abstract

No standard treatments have been established for airway hemorrhage during cardiopulmonary bypass (CPB). Herein, we describe two cases of catheter-induced pulmonary hemorrhage during cardiac surgery. In each case, massive hemoptysis was observed during cardiopulmonary bypass (CPB) weaning. A bronchial blocker was inserted into the right bronchus, and extracorporeal membrane oxygenation (ECMO) was initiated to reduce pulmonary blood flow, and stabilize the hemodynamics. ECMO significantly reduced bleeding from the pulmonary artery (PA). Both cases had favorable outcomes following the implementation of extracorporeal membrane oxygenation (ECMO). ECMO is effective at controlling PA bleeding during and after cardiac surgery.

Extracorporeal membrane oxygenation for the control of a pulmonary artery hemorrhage

Yuichiro Hirata, MD, PhD, Eiki Tayama, MD, PhD, Ryuya Nomura, MD, Tomofumi Fukuda, MD, Tatshushi Onzuka, MD, PhD, Kojiro Furukawa, MD, PhD, Shigeki Morita, MD, PhD

Department of Cardiovascular Surgery, Clinical Research Institute, Kyusyu Medical Center, National Hospital Organization

1-8-1 Jigyohama, Chuouku, Fukuoka, Fukuoka, Japan

Running title: ECMO for Pulmonary Hemorrhage

Corresponding author: Yuichiro Hirata

810-0065 1-8-1 Jigyohama, Chuouku, Fukuoka, Fukuoka, Japan

FAX: +81-092-847-8802

TEL: +81-092-852-0700

hiratay22@gmail.com

Abstract

No standard treatments have been established for airway hemorrhage during cardiopulmonary bypass (CPB). Herein, we describe two cases of catheter-induced pulmonary hemorrhage during cardiac surgery. In each case, massive hemoptysis was observed during cardiopulmonary bypass (CPB) weaning. A bronchial blocker was inserted into the right bronchus, and extracorporeal membrane oxygenation (ECMO) was initiated to reduce pulmonary blood flow, and stabilize the hemodynamics. ECMO significantly reduced bleeding from

the pulmonary artery (PA). Both cases had favorable outcomes following the implementation of extracorporeal membrane oxygenation (ECMO). ECMO is effective at controlling PA bleeding during and after cardiac surgery.

Introduction

Many cases of airway hemorrhage during cardiopulmonary bypass (CPB) weaning have been reported. Bronchial blocker insertion and lung resection are performed for its management, but no standard treatment has been established. By introducing extracorporeal membrane oxygenation (ECMO), we were able to reduce pulmonary artery (PA) blood flow, and therefore, significantly reduce bleeding in two cases of catheter-induced pulmonary hemorrhage. For both patients, the bronchial blocker was removed the day after surgery, while ECMO was withdrawn four days later. Tracheal bleeding did not recur during the postoperative period.

Case reports

Need for ethical approval was waived off by institutional review board. Both cases provided informed consent for the publication of this study.

Case one

A 66-year-old man underwent total aortic arch replacement and coronary artery bypass grafting for thoracic aortic aneurysm and coronary artery stenosis.

An endotracheal double lumen tube and a PA catheter were inserted (45 cm). Total aortic arch replacement and coronary artery bypass grafting were performed, and while attempting CPB withdrawal, an anesthesiologist reported increased bleeding in the trachea. Bronchoscopy revealed bleeding in the right bronchus, and a bronchial blocker was immediately inserted. The right lung was darkish red in color and hardened (Fig.1). A catheter-induced PA injury was suspected, so the catheter was withdrawn by 5 cm. Following the introduction of ECMO, the patient was withdrawn from CPB, and heparin was reversed halfway, using protamine (activated clotting time: 150–180 s). Looking at the patient's perioperative X-ray image retrospectively, the PA catheter was bent (Fig. 2-A), and a postoperative X-ray image revealed decreased permeability of the right lung field (Fig. 2-B).

Once in the intensive care unit (ICU), the patient had no obvious intratracheal bleeds. On postoperative day (POD) 1, the bronchial blocker was removed and no bleeding was observed in the trachea, although decreased permeability in the right lung field persisted (Fig. 2-C), and oxygenation ability was poor. Nitric oxide (NO) inhalation was initiated on POD 3 and oxygenation ability as well as right lung field permeability gradually improved (Fig 2.-D). It was subsequently possible to withdraw ECMO on POD 4. NO inhalation was discontinued on POD 6; the patient was extubated on POD 7, and discharged from the hospital on the POD 30.

Case two

A 69-year-old woman underwent mitral valve repair, tricuspid annuloplasty, pulmonary vein isolation, and left atrial appendage resection for mitral insufficiency, tricuspid insufficiency, and atrial fibrillation, respectively.

An endotracheal tube and a PA catheter were inserted (48 cm). During CPB withdrawal, echography revealed dissection of the ascending aorta, and an intimal fissure at the insertion point of the cardioplegia needle. Ascending and aortic arch replacements were performed, and a large amount of blood was observed in the tracheal tube during CPB withdrawal. A PA injury due to the PA catheter appeared to have occurred, and a bronchial blocker was inserted into the right bronchus immediately. ECMO was initiated after withdrawal from CPB, without heparin. Subsequently, the bleeding into the bronchial tube decreased. Looking at the patient's perioperative X-ray image retrospectively, the PA catheter was bent (Fig. 3-A), and a postoperative X-ray image revealed significantly decreased permeability of the entire right lung field (Fig. 3-B).

Once in the ICU, the patient experienced no obvious intratracheal bleeding. On POD 1, the bronchial

blocker was removed, no bleeding into the trachea was observed, and the permeability of the right lung field had improved (Fig. 3-C). A cardiac tamponade due to an intracardiac hematoma was observed; therefore, re-exploration was performed on the same day. The patient was withdrawn from ECMO on POD 4, and X-ray images revealed general improvement in the permeability of the right lung (Fig.3-D). However, the oxygenation ability had decreased. NO inhalation was initiated, and on POD 12, the patient was weaned from this treatment. Thereafter, a tracheotomy was performed on POD 15 and the tracheal cannula was removed on POD 60. The patient was transferred to a rehabilitation facility on POD 102.

Discussion

PA catheters are widely used., and although complications associated with their use have been reported. Intratracheal bleeding during cardiac surgery only occurs in 0.001–0.47% of cases, but mortality is high at 70%1, with no uniform treatment for this lethal complication.

The main purpose of a bronchial blocker is to protect a healthy lung from blood trickling in. Although hemostatic effect is insufficient, this procedure often has a relatively good outcome. In 93% of cases, it is the right PA that sustains a catheter associated injury.2 Since it is not possible to determine which bronchus is bleeding, it may be most appropriate to insert the blocker in the right bronchus; insertion is possible even with a single endotracheal tube.3

Pulmonary resection has long been used as a treatment for PA bleeding. However, this procedure is invasive and often has a poor outcome. Sirivella et al. reported that it was possible for a pulmonary resection to control pulmonary hemorrhage, but that it did not reduce mortality.4 Booth et al. stated that lobectomies for bleeding increase mortality and morbidity, and that less invasive treatments should be used.5

Since catheterization laboratories can identify hemorrhaging vessels via angiography, coil embolization could be utilized. Most cases involve the central PA which often allows for endovascular treatment. Embolization of the central side of the PA inhibits antegrade blood flow; thus, hemostasis can be achieved using a stent graft6 or vascular plug.7 Some surgeons perform pulmonary artery banding during open surgery.

We had previously reported the effectiveness of NO inhalation for reduced oxygenation associated with airway bleeding due to a PA injury.8 NO inhalation selectively increases the blood flow to the residual alveoli, thereby improving the ventilation-perfusion mismatch.

To our knowledge, there have been no reports addressing the effectiveness of ECMO in reducing PA bleeding. By introducing ECMO, blood flow in the PA was significantly reduced, making it possible to suppress bleeding. Although there are concerns about bleeding associated with the use of heparin, no complications including pulmonary hemorrhage were observed by performing half reversal with protamine. We obtained a good clinical outcome using ECMO for two cases of catheter-induced pulmonary hemorrhage. The use of ECMO reduced PA blood flow, and controlled the bleeding volume.

Conflict of interests

The authors declare no conflict of interest.

Author contributions: HY: Author, Concept, ET, KF: Surgery, SM: Concept, RN, TF, TO: Data acquisition

References

1. Kearney TJ, Shahot MM. Pulmonary artery rupture associated with the Swan-Ganz catheter. Chest 1995;108:1349-1352.

2. Urschel JD, Myerowitz PD. Catheter-induced pulmonary artery rupture in the setting of cardiopulmonary bypass. Ann Thorac Surg 1993;56:585-589.

3. Neerukonda T, Gibson WJ, Abicht T, Sauer A, Flynn B. Pulmonary artery rupture management with a single lumen endotracheal tube: old tricks that should be revisited. Am J Case Rep 2018;19:342-346.

4. Sirivella S, Gielchinsky I, Parsonnet V. Management of catheter-induced pulmonary artery perforation: a rare complication in cardiovascular operations. Ann Thorac Surg 2001;72:2056-2059.

5. Booth KL, Smith GM, McConkey C, Parissis H. Catheter-induced pulmonary artery rupture: haemodynamic compromise necessitates surgical repair. Interact Cardiovasc Thorac Surg 2012;15:531-533.

6. Zuffi A, Zoccai GB, Colombo F. Swan-Ganz-induced pulmonary artery rupture: management with stent graft implantation. Catheter Cardiovasc Interv 2010;76:578-581.

7. Kalra A, Heitner S, Topalian S. Iatrogenic pulmonary artery rupture during Swan–Ganz catheter placement—a novel therapeutic approach. Catheter Cardiovasc Interv 2013;81:57-59.

8. Hirata Y, Tayama E, Morita S, et al. A case of inhaled nitric oxide (NO) effect on the hemodynamics and oxygenation decrease in endotracheal hemorrhage during extracorporeal circulatory surgery. J Jpn Soc Intensive Care Med 2020;27:32-36.

Figure legends

Figure 1. Gross pulmonary findings in case 1, following discovery of a bleed in the right bronchus. The right lung was darkish red in color.

Figure 2. Transition of the X-ray findings for case 1. (a) Before the operation, (b) after the operation, (c) on POD 1, and (d) on POD 4.

Figure 3. Transition of the X-ray findings for case 2. (a) Before the operation, (b) after the operation, (c) on POD 1, and (d) on POD 4.