

Preoperative balloon pulmonary angioplasty enabled noncardiac surgery of a patient with chronic thromboembolic pulmonary hypertension (CTEPH)

A case report

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Abstract

Rationale: Chronic thromboembolic pulmonary hypertension (CTEPH) is a disease with a poor prognosis, characterized by chronic thromboembolic obstruction of the pulmonary arteries and pulmonary hypertension. Balloon pulmonary angioplasty (BPA) is a newly emergent treatment for CTEPH, which may substitute pulmonary endarterectomy, the standard but more invasive treatment for CTEPH. Here, we report the case of a CTEPH patient who underwent 2 noncardiac surgeries without complications after preoperative intervention of BPA.

Patient concerns: A 79-year-old man presented with severe osteoarthritis of bilateral knees, with adaptation of total knee arthroplasty (TKA). Transthoracic echocardiogram revealed severe pulmonary hypertension with estimated right ventricular systolic pressure of 140 mm Hg.

Diagnosis: Pulmonary arteriography revealed total occlusion of the upper branch of the right pulmonary artery, and ventilation/perfusion scan showed multiple mismatched perfusion defects. His pulmonary artery pressure (PAP) was as high as 89/25 (46) mm Hg with normal range of pulmonary capillary wedge pressure. He was diagnosed with CTEPH.

Interventions: Four BPA sessions for 8 branches of the bilateral pulmonary arteries were done, until the mean PAP (mPAP) went under 30 mm Hg. For the TKA, we selected spinal anesthesia in order to minimize intraoperative hemodynamic changes. Cardiac surgeons were standby in case extracorporeal membrane oxygenation (ECMO) initiation was required.

Outcomes: With appropriate pain management and use of intravenous vasopressors, intraoperative vital signs were stable. No symptoms of hemodynamic collapse were observed postoperatively. The patient was discharged on the 46th postoperative day following rehabilitation. Two years later, left-side unicompartment knee arthroplasty (UKA) was scheduled. Right heart catheterization study revealed the mPAP was 30 mm Hg, nearly the same value as the last study. The operation was performed under spinal anesthesia with continuous arterial pressure monitoring without need for intraoperative vasopressor. He was discharged without complications on the 24th postoperative day.

Lessons: BPA can be an effective preoperative intervention for CTEPH patients undergoing noncardiac surgery.

Abbreviations: APTT = activated partial thromboplastin time, BPA = balloon pulmonary angioplasty, CTEPH = chronic thromboembolic pulmonary hypertension, ECMO = extracorporeal membrane oxygenation, mPAP = mean pulmonary pressure, PEA = pulmonary endarterectomy, PH = pulmonary hypertension, TKA = total knee arthroplasty.

Keywords: balloon pulmonary angioplasty, chronic thromboembolic pulmonary hypertension, pulmonary hypertension

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Written informed consent was obtained from the patient for the publication of this report.

The authors have no conflicts of interest to disclose.

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1. Introduction

Chronic thromboembolic pulmonary hypertension (CTEPH) is a rare type of pulmonary hypertension characterized by chronic thromboembolic obstruction of pulmonary arterial branches, and is categorized into group 4 pulmonary hypertension (PH) by the World Health Organization (WHO) Classification of PH.^[1,2] CTEPH has a poor prognosis because it is associated with elevated pulmonary arterial pressure (PAP) and consequent progressive right-sided heart failure; the 1-year and 3-year survival rates have been reported as 82% and 70%, respectively.^[3] Pulmonary endarterectomy (PEA) is the only established treatment for advanced CTEPH,^[4] but it must be performed under deep hypothermic circulatory arrest and is only available at a limited number of institutions. Balloon pulmonary angioplasty (BPA) is a newly emergent treatment for CTEPH that is performed percutaneously and less invasively. BPA improves the pulmonary hemodynamic state as successfully as PEA, and has a much greater effect on mortality and quality of life than medication therapy alone.^[5,6] No previous reports have demonstrated the efficacy of BPA as a preoperative intervention for pulmonary hypertensive patients.

Here, we report the case of a patient with CTEPH who was treated with BPA preoperatively and tolerated 2 noncardiac operations with no complications.

2. Method

We report an observational case of an anesthesia management of a noncardiac operation of CTEPH patient following BPA treatment. The ethics committee waived the requirement of approval to conduct this single case study with access to medical records. Informed consent for publication has been obtained from the patient.

3. Case report

Six months prior to his admission at our institution, a 79-year-old man (height 147 cm, weight 68 kg) with severe osteoarthritis of his bilateral knees was found to have bilateral lower leg edema and physically examined at another hospital. Transthoracic echocardiogram and computed tomography (CT) revealed severe pulmonary hypertension (estimated right ventricular systolic pressure of 140 mm Hg) and chronic pulmonary thromboembolism. Oral warfarin was started for anticoagulation. Although the patient required right side total knee arthroplasty (TKA), the examining hospital and another subsequent hospital declined to operate due to the patient's severe PH. He was therefore referred to our institution.

The patient was in a wheel chair on admission due to severe knee pain. He did not present with dyspnea nor chest symptoms. The contrast-enhanced CT (Fig. 1A) and pulmonary arteriography (Fig. 1B) revealed thrombotic obstruction of the upper branch of the right side pulmonary artery. Mismatched perfusion defects in the upper lobe and multiple wedge-shaped defects in bilateral lung fields were observed in the ventilation/perfusion scans (Fig. 1C). Transthoracic echocardiogram showed dilated right ventricle and right atrium, which implied elevated PAP (Fig. 1D). A right heart catheterization study revealed high PAP with normal pulmonary capillary wedge pressure, as shown in Table 1. This result denied "PH due to left-side heart disease" (WHO group 2 PH). The venous ultrasound of the lower limbs

showed old thrombosis in the popliteal and femoral veins bilaterally.

These findings led to the diagnosis of CTEPH. Because thrombi were found in the 2nd branch levels of the right pulmonary artery, the patient was considered eligible for BPA treatment. Four BPA sessions for 8 branches of the right pulmonary artery were performed by interventional cardiologists after the patient received proper informed consent in our institution. The PAP decreased through those BPA sessions, from 89/25(46) mm Hg to 53/17(29) mm Hg (Table 1).

Preoperative arterial blood gas analysis showed moderate impairment in oxygenation, with a partial oxygen tension (PaO₂) of 60.2 mm Hg, partial carbon dioxide tension (PaCO₂) of 31.9 mm Hg, and pH of 7.42 in ambient air.

To the patient and his family, we explained the possibility of intraoperative right ventricular dysfunction following PAP surge, mechanical ventilation, and the potential necessity of initiating mechanical circulatory support (i.e., extracorporeal membrane oxygenation) for lifesaving purposes. They accepted these risks, and the TKA was scheduled. The patient strongly refused pulmonary artery catheter (PAC) placement due to a previous failure with PAC insertion. We therefore chose systemic invasive blood pressure (IBP) and central venous pressure (CVP) except for PAP for the invasive hemodynamics monitoring. We arranged for cardiac surgeons to be standby in case ECMO initiation was required at any time during the operation. Warfarin was discontinued preoperatively, and intravenous heparin was administered in order to maintain the activated partial thromboplastin time (APTT) at 50 seconds for 7 days. Eight hours before the operation the heparin was discontinued.

We selected combined spinal and epidural anesthesia with isobaric 0.5% bupivacaine for spinal anesthesia and continuous 0.2% ropivacaine for epidural anesthesia, since the value of APTT returned to the normal range on the morning of the operation day. After central venous catheter insertion, epidural and spinal anesthesia was performed. The epidural catheter was placed from the Th11/Th12 intervertebral space, and then 3 mL of isobaric 0.5% bupivacaine was injected intrathecally from the L3/L4 intervertebral space as spinal anesthesia. Analgesia level was below the Th5 bilaterally. Low doses of continuously infused norepinephrine (0.05 µg/kg/min) and phenylephrine (0.1 µg/kg/min) were administered to maintain the systolic IBP in a range of 100 to 120 mm Hg. Oxygen was administered at 3 L/min during the operation to prevent hypoxia and increase of pulmonary vascular resistance. The tourniquet was deflated in 20 mm Hg steps to minimize hemodynamic changes. Continuous monitoring of both IBP and CVP showed minimal change throughout the operation. The operation time was 2 hours and 15 minutes and the total amount of bleeding was 340 g. With continuous epidural analgesia of 0.2% ropivacaine, no postoperative pain was observed. The epidural catheter was removed on the day after the operation, and continuous intravenous heparin was resumed 5 hours later. The patient was discharged on the 46th day after the operation without complications.

Two years after the first operation, he developed severe left knee osteoarthritis. Unicompartment knee arthroplasty (UKA) was scheduled. A right heart catheterization study was performed as a preoperative evaluation, and revealed nearly the same range of mean PAP (30 mm Hg) as 2 years before (Table 1). This time, the operation was scheduled without additional BPA. Based on our experience of intraoperative hemodynamic stability and adequate analgesia during the first operation, we selected spinal anesthesia only, without continuous CVP monitoring. Heparin

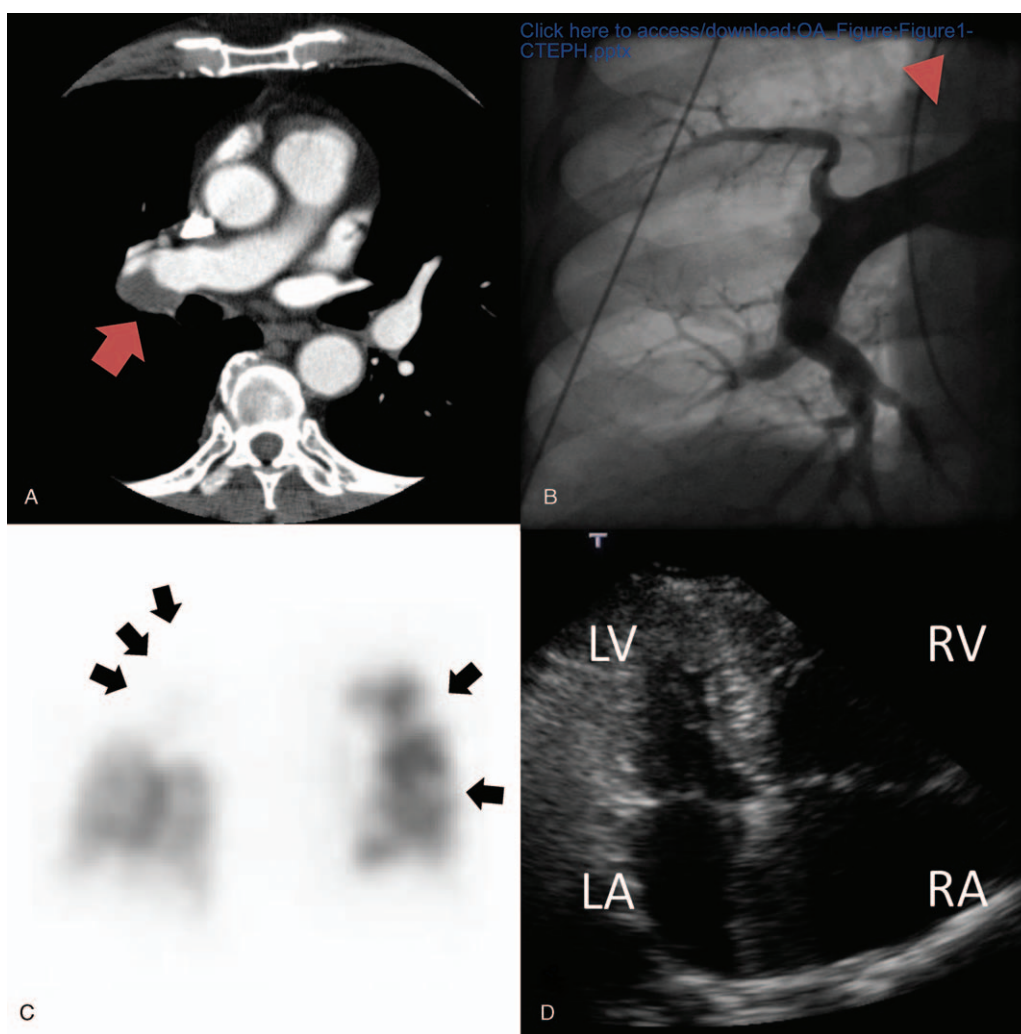


Figure 1. Pre-BPA image findings. A, Contrast-enhanced CT showed thrombi occupying the right upper pulmonary artery (red arrow). B, Pulmonary arteriography revealed total occlusion of the upper branch of the right pulmonary artery (red arrowhead). C, Coronal view of the ventilation/perfusion scans with mismatched perfusion defects in the right upper lobe and multiple wedge-shaped defects in bilateral lung fields (arrows). D, Transthoracic echocardiogram showed dilated right ventricle and right atrium. BPA=balloon pulmonary angioplasty, LA=left atrium, LV=left ventricle, RA=right atrium, RV=right ventricle.

Table 1

Data of right heart catheterization studies.

	Pre-BPA	Post-BPA (before 1st operation)	Post-BPA (before 2nd operation)
HR (/min)	62	60	53
RA (mm Hg)	15/12 (11)	8/7 (7)	10/6 (6)
RV (mm Hg)	87/EDP15	57/EDP9	65/EDP7
PA (mm Hg)	89/25 (46)	53/17 (29)	65/15 (30)
PCWP (mm Hg)	22/18 (17)	14/10 (11)	10/9 (8)
LV (mm Hg)		116 / EDP8	

BPA=balloon pulmonary angioplasty, EDP=end-diastolic pressure, HR=heart rate, LV=left ventricle, PA=pulmonary artery, PCWP=pulmonary capillary wedge pressure, RA=right atrium, RV=right ventricle. Pressures are described as [highest pressure]/[lowest pressure] ([mean pressure]). In the RV and LV, pressures are described as [highest pressure]/[end-diastolic pressure].

was also administered to maintain an APTT value of 50 seconds for 7 days, and discontinued 8 hours before the operation.

A dose of 2.6 mL of isobaric 0.5% bupivacaine was injected intrathecally from the L4/L5 intervertebral space, and analgesia level was below the Th12 bilaterally. Oxygen was administered at 3 L/min during the operation. The systolic IBP was kept around 100 mm Hg throughout the operation without need of phenylephrine or other vasopressor infusion. This time, the surgeon willingly agreed not to use a tourniquet, since we emphasized the likelihood of a change in RV preload upon tourniquet deflation. The operation time was 1 hour and 40 minutes and the estimated blood loss was 170 g. Continuous infusion of fentanyl (25 µg/h) was used for postoperative pain. He was discharged on the 24th day after the operation without complications.

4. Discussion

CTEPH is a class of PH characterized by chronic obstruction of large pulmonary arteries due to the formation of organized thrombi. CTEPH is treated with specific strategies distinct from those applied for other types of PH.^[1,2] The only established and potentially curative treatment for CTEPH is PEA,^[4] but patients ineligible for PEA are treated with pulmonary hypertension-specific drugs or with BPA.^[7,8] BPA, first performed in 1983 for pediatric patients,^[9] has recently emerged as a primary and adjunctive treatment for CTEPH patients at expert centers. BPA is accompanied by the potential risk of reperfusion pulmonary edema and lung injury. Recent advancement of BPA procedure shows improvement of its safety and effectiveness.^[10] The BPA outcome from a multicenter registry in Japan with a total of 308 patients was recently reported^[11]; although the complication rates remained high, the overall survival was comparable to that by PEA. Therefore, it may be an important therapeutic option for patients with CTEPH, especially those ineligible for PEA. The prognosis of CTEPH is poor if untreated, especially in patients whose mean PAP exceeds 30 mm Hg.^[12] The degree of PH is the most important factor to determine whether a patient can accept a noncardiac surgery. In this case, the mean PAP was reduced to 29 mm Hg after the BPA treatments, and we assessed that the patient could tolerate the anesthesia and operation.

PH is a serious risk factor for perioperative complications.^[13] Patients with PH undergoing noncardiac surgery are more likely to develop postoperative right heart failure, hemodynamic instability, sepsis, and respiratory failure, and the mortality rate of PH is significantly high.^[14] Various factors, such as mechanical ventilation, pain, hypoxia, acidosis, hypercapnia, and air or fat emboli, can lead to pulmonary vasoconstriction and elevated pulmonary arterial pressure, which potentially results in fatal PH crisis (defined as a PAP equal to or greater than systemic arterial pressure) and subsequent right ventricular dysfunction.^[15] Preventing PH crisis is thus the key to successful perioperative management of patients with PH.

In this case, we took all conceivable measures to prevent an increase in PAP. To achieve maximal analgesia, in both operations we chose conventional and familiar neuraxial anesthesia: combined spinal and epidural anesthesia for the first, and spinal anesthesia for the second. Because mechanical ventilation potentially increases pulmonary arterial resistance, we did not choose general anesthesia. Another option was peripheral nerve block—for example, combined sciatic nerve block and continuous femoral nerve block but in our institution it

was not common practice at that time. The choice of epidural anesthesia for a CTEPH patient involved a risk, since there was the possibility of intraoperative ECMO initiation that would require anticoagulant therapy. We explained the patient both advantage and disadvantage of epidural anesthesia in usage of anticoagulant drug, and combined spinal and epidural anesthesia was chosen. In both operations, oxygen was administered in order to avoid hypoxia, which would increase PAP.

Continuous PAP monitoring with PAC might have provided useful information, especially under general anesthesia. However, we considered that PAP monitored by PAC would not necessarily reflect PAP accurately in CTEPH patients, because this monitoring is dependent on the placement of the PAC tip. In addition, the patient refused even after we emphasized the importance of the monitoring, because he was strongly concerned about the possible complications of PAC.^[16] It could be substitutable with measuring central venous oxygen saturation (ScvO₂).

5. Conclusion

This is the first report of the anesthetic management of a patient with CTEPH, after improving his PH with BPA. BPA could be a preoperative interventional option to minimize the perioperative risks of CTEPH patients.

Author contributions

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