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Case Report

Anesthesia management in an elderly patient with pulmonary hypertension reported by echocardiography during lumbar fusion: a case report

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Abstract: Anesthesia management in elderly patients with pulmonary hypertension (PH) is complex and challenging for anesthesiologists. For a patient with PH to endure the perioperative period smoothly and without serious complications, such as cardiopulmonary problems, careful, comprehensive evaluation is crucial. We present the case of a 73-year-old male patient with severe PH being prepared for anterior lumbar interbody fusion and vertebroplasty. Anesthesia management was designed to maintain pulmonary vascular resistance and appropriate cardiac output and ensure the perfusion of vital organs. We conducted a preoperative evaluation with multidisciplinary consultations for this patient and used hemodynamic indicators such as central venous pressure (CVP), stroke volume variation (SVV), and cardiac output (CO), adequate sedation, analgesia, and anti-stress management during general anesthesia. The operation was successful, with no respiratory or cardiovascular complications.

Keywords: General anesthesia, elderly patient, severe pulmonary hypertension, pulmonary vascular resistance, lumbar fusion

Introduction

Pulmonary hypertension (PH) is a chronic and progressive disease that gradually leads to heart dysfunction of the right side and possibly heart failure. The proposed definition for PH (per the Sixth World Symposium on PH) is a mean pulmonary artery pressure of greater than 20 mmHg [1]. The 6th World Symposium on Pulmonary Hypertension in 2019 updated the clinical classification of PH to include: Group 1) PAH (pulmonary arterial hypertension); Group 2) PH due to left side heart disease; Group 3) PH due to lung diseases and/or hypoxia; Group 4) PH due to pulmonary artery obstructions, including (4.1) Chronic thromboembolic PH and (4.2) Other pulmonary artery obstructions; Group 5) PH with unclear and/or multifactorial mechanisms. All forms of PH may eventually affect arterial and venous pathologic remodeling, thus resulting in a decrease in CO and an increase in pulmonary vascular resistance. A study suggested that anesthetic-related morbidity was 27% in patients with pulmonary arterial hypertension undergoing noncardiac surgery [2]. Therefore, severe PH [The systolic pulmonary artery pressure (SPAP): 103 mmHg] in our present case increased the perioperative risks, which presented great challenges to our anesthesiologists during anesthesia management. Sufficient perioperative preparation, including adequate perioperative evaluation, careful design of the anesthesia program, the use of intraoperative PH-targeted therapy, and a well-established multidisciplinary team [2], ensures the safety of the patient with PH and the successful completion of the operation. In our case, presented here, the patient was fully prepared for his operation and premedicated by our multidisciplinary team that included anesthesiologists, neurosurgeons, a vascular surgeon, and cardiologists.

Case report

A 73-year-old man presented to our hospital with an 11-year history of low back pain with no obvious cause and 5 months of bilateral lower limb radiation pain. The patient's symptoms had worsened during the past 2 months. The

patient was initially diagnosed with an L3-5 intervertebral disc bulge and spinal stenosis at the level of the L4-S1 disc.

Past history

The patient was diagnosed with left lower extremity deep vein thrombosis 11 years ago and pulmonary embolism 5 years ago. He took oral aspirin enteric-coated tablets until six months ago, 100 mg, q.d. (once a day), then switched to warfarin, 1 tablet, q.n. (every night) until admission to our hospital, and took long-term (exact time span was unknown) oral digoxin, half-tablet, q.d. The patient had a history of shortness of breath and discomfort while walking.

Preoperative laboratory examination and imaging findings

The patient's routine blood tests and blood biochemical indexes were all normal. Blood gas analysis (BGA) showed that arterial oxygen partial pressure (PaO_2) at 68.3 mmHg was below the normal range. The patient's blood coagulation function showed an increased international normalized ratio (INR) (1.88 (normal (N): 0.8-1.2)) and prothrombin time (21.5 seconds (N: 11-15)), but decreased prothrombin activity (42.0% (N: 70%-120%)); Plasma D-dimer 0.36 ug/ml was in the normal range (0.01-0.5). A pulmonary function test revealed that the patient's pulmonary gas exchange was decreased by measuring the diffusing lung capacity for carbon monoxide (DLCO) of 5.79 mmol/min/kPa. A chest X-ray showed infection of the lower right lung and heart image enlargement. Lumbar plain computed tomography (CT) study and CT three-dimensional reconstruction showed prolapse of the lumbar intervertebral disc at the level of L5-S1 and spinal stenosis at the level of the L4-S1 disc. Dilatation of the right heart (transverse diameter of the right atrium = 60 mm) and left atrial enlargement were evident on the echocardiograph. SPAP was 103 mmHg. Echocardiography of the patient showed an ejection fraction (EF) of 63%, CO of 3.3 L/min, stroke volume (SV) of 62 ml, and mitral valve E/A ratio >1. The left ventricular diastolic function of the patient was decreased, and slight mitral regurgitation and moderate tricuspid valve regurgitation were found. Abnormalities of the lower extremity vein blood flow frequency spectrum and plexus venosus leg muscle thrombosis were found by vascular ultrasound testing.

Anesthetic management

Pre-induction monitoring: The patient was taken into the operating room and positioned comfortably in a supine position on a thermal mattress in preparation for an anterior lumbar interbody fusion and vertebroplasty. Standard monitoring included a 5-lead electrocardiogram catheter inserted in his left radial artery for invasive blood pressure (BP) measurement, and a pulse oximeter placed on a finger of his right hand. Bispectral index (BIS) monitoring was used to observe the intraoperative depth of sedation in real time and to adjust the dosage of anesthetic drugs. A Vigileo monitor (Edwards Lifesciences LLC Irvine, CA 92614-5686 USA, USA) was used to monitor hemodynamic parameters, such as CO and SVV, to guide fluid infusion and drug management. The patient [weight: 55 kg; height: 1.68 m; Body Mass Index(BMI): 19.5 kg/m^2] was in poor health, with a pulse of 45-72 beats/min, noninvasive blood pressure (NBP) of 114/77 (87) mmHg, invasive blood pressure (IBP) of 137-148/68-69 (90-93) mmHg, irregular heart sounds consistent with the electrocardiograph (ECG) findings of atrial fibrillation, pulse oxygen saturation (SPO_2) of 95%, and BIS of 95. Conventional ECG showed that the ST-segment of standard lead II was decreased by 1.4 mm and was accompanied by atrial fibrillation and occasional premature ventricular beats. The Vigileo monitor showed that the CO and SVV were 4.5 L/min and 14%, respectively, for the patient. A cardiac ultrasound probe, used to observe the patient's four-chamber heart, showed that the right atrium and the right ventricle were dramatically enlarged.

Upon entry to the operating room, the patient had a heart rate (HR) of <50 beats/min, and the number of premature ventricular beats was frequent. A small amount of atropine (0.3 mg) was administered to increase the HR to 70-80 beats/min and as a result, the number of premature ventricular beats obviously decreased.

Induction of general anesthesia: Methylprednisolone 40 mg, ondansetron 4 mg, and dexamethasone 5 mg were given to the patient before the induction of general anesthesia. After full preoxygenation, anesthesia was

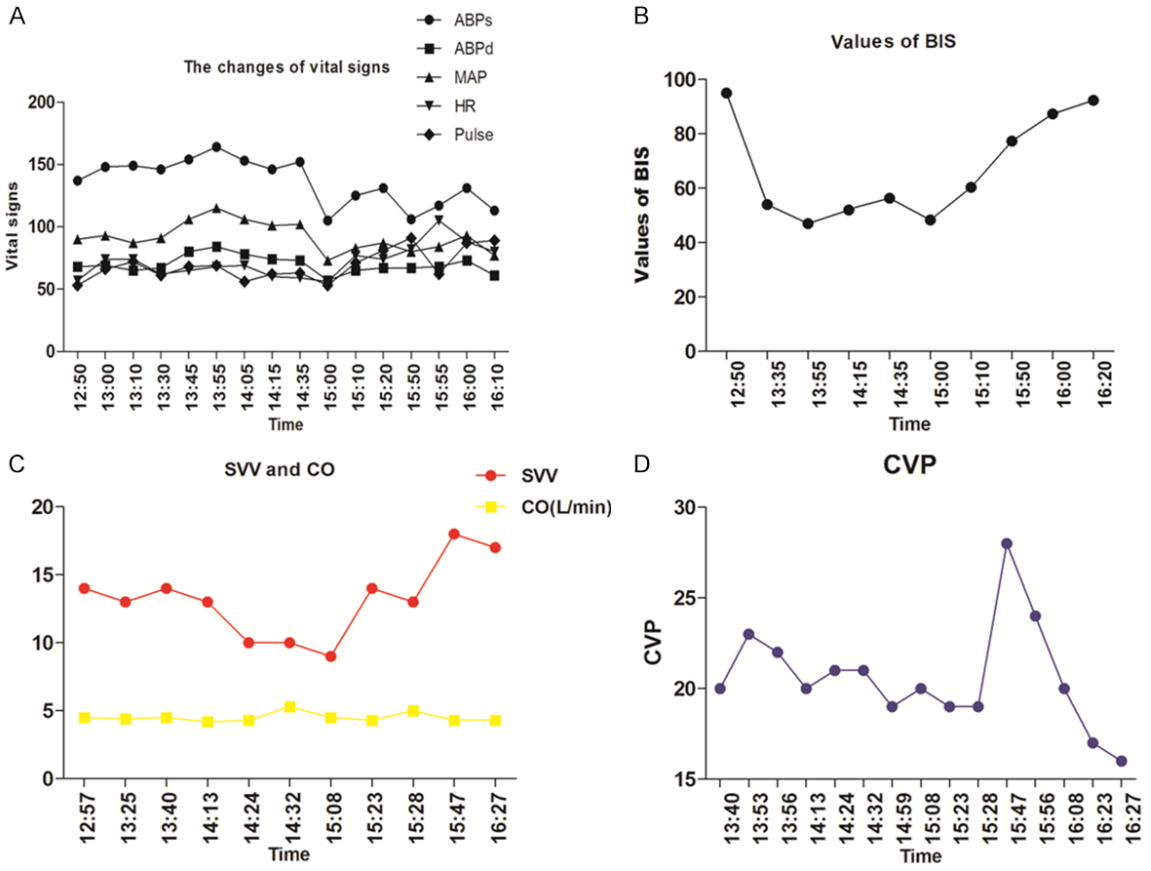

Figure 1. Patient parameters during the operation. A. Vital signs. B. Bispectral index (BIS) values. C. Stroke volume variation (SVV) and cardiac output (CO) values. D. Central venous pressure (CVP) values were relatively stable throughout the procedure, but increased suddenly before the endotracheal tube was removed.

induced by intravenous administration of etomidate 10 mg, sufentanil 20 μg in two doses (10 μg + 10 μg), and cisatracurium 12 mg. Simultaneously, a continuous drug infusion including remifentanil: 0.2-0.35 μg/kg/min, propofol: 2-4 mg/kg/h, dexmedetomidine: 0.2-0.25 μg/kg/h, norepinephrine: 0.03-0.05 μg/kg/min, dobutamine: 2-3 μg/kg/min was started at small doses and gradually increased until the patient reached a suitable depth of anesthesia while maintaining hemodynamic stability. Smooth intubation with a 7.5# endotracheal tube was completed with small fluctuations in various hemodynamic parameters. The patient was ventilated with a fractional inspired oxygen concentration (FiO_2) of 40%, a tidal volume (V_T) of 6-8 mL/kg (400 ml), a respiratory rate of 12 breaths/min, I:E = 1:2, and a positive end expiratory pressure (PEEP) of 0 cm H_2O.

After induction of general anesthesia, the patient was on mechanically controlled breathing and a central jugular vein puncture and catheterization were performed for the measurement of CVP and the administration of vasoactive drugs.

Maintenance of intraoperative anesthesia

Intraoperative anesthesia was maintained with remifentanil at 0.3-0.4 μg/kg/min, propofol at 4 mg/kg/h, dexmedetomidine at 0.2 μg/kg/h, norepinephrine at 0.02-0.05 μg/kg/min, and dobutamine at 2-3 μg/kg/min. Vital signs and hemodynamic parameters remained relatively stable during the operation (**Figure 1A**), and their changes were as follows: IBP (120-160/60-80) mmHg, HR (60-75) bpm, temperature (T) (36.1°C-36.4°C), end-tidal CO_2 partial pressure ($PetCO_2$) (29-33) mmHg, BIS (40-60), SpO_2 (99-100)%, CO (4-6) L/min, SVV (8-14)%.

Intraoperative change of various detection indicators in the patient

BIS: Changes in BIS values during the operation are shown in **Figure 1B**.

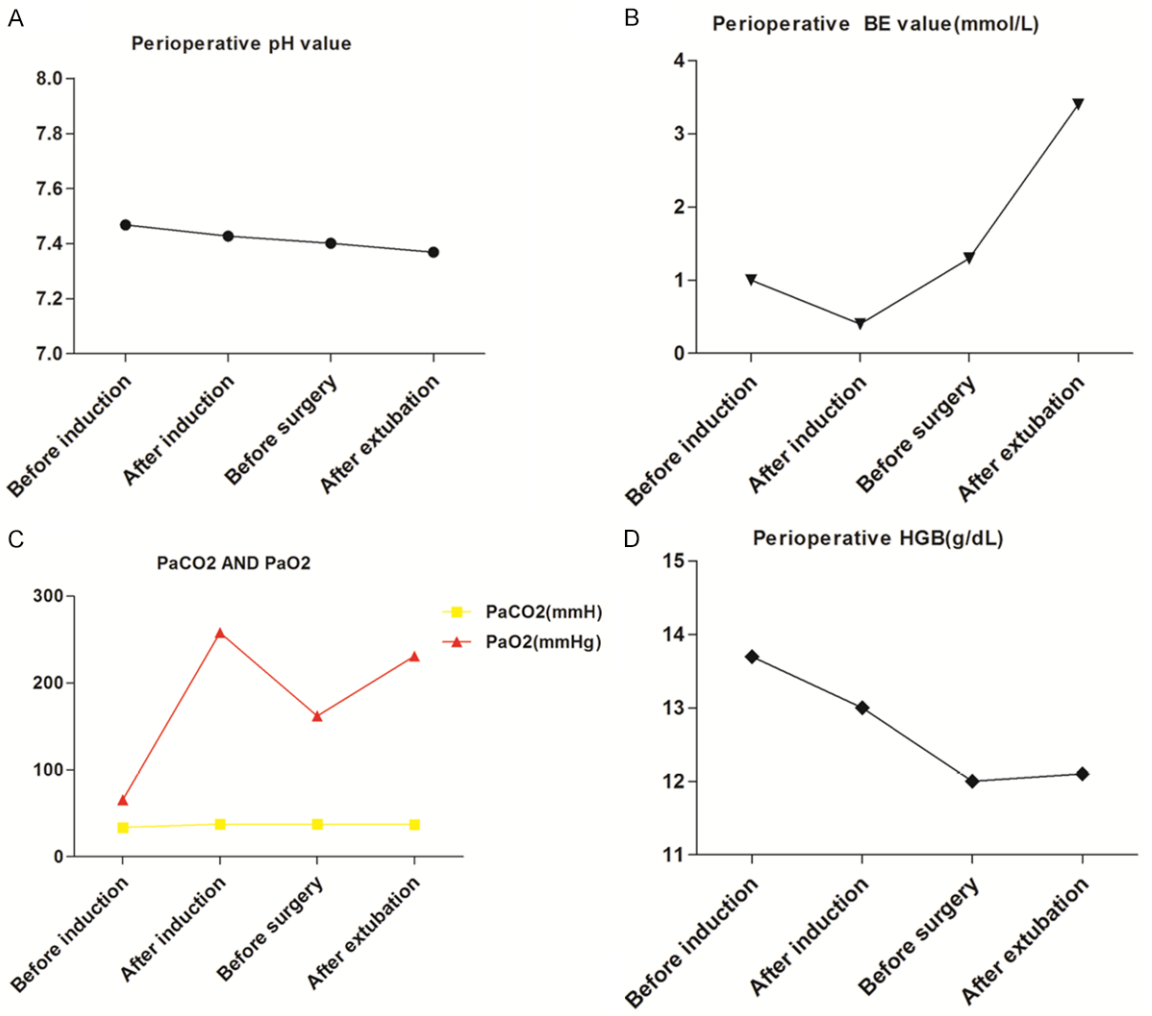

Figure 2. Blood gas analysis (BGA) at key time points during the operation. A. The value of pH. B. The value of base excess (BE). C. Arterial partial pressure of carbon dioxide ($PaCO_2$) and arterial partial pressure of oxygen (PaO_2). D. Hemoglobin (HGB) concentration. Perioperative BGA data showing normal acid-base balance and normal electrolyte levels and small amount of blood loss.

The BIS value is used to measure the depth of anesthesia. During the operation, the BIS was properly maintained between 47 and 60, and upon completion of the operation it increased to 89-92, and the patient was awakened.

SVV and CO: Changes of SVV and CO during the operation are shown in **Figure 1C**.

The SVV was stable at 9%-14% throughout the operation under general anesthesia. The patient's CO values remained stable at 4.5-5 L/min throughout the operation, which was consistent with preoperative levels.

CVP: Changes in intraoperative CVP are shown in **Figure 1D**.

The CVP was relatively stable between 19 and 23 cm H_2O throughout the operation, but increased to 24-28 cm H_2O before the tracheal tube was removed after the operation. After the tracheal tube was removed, the CVP decreased to 17-20 cm H_2O, and it further decreased to 16 cm H_2O before the patient left the operating room.

Intraoperative blood gas analysis (BGA): The BGA values during the operation are shown in **Figure 2A-D**.

Arterial BGA was performed intermittently throughout the operation to monitor the patient's acid-base status, electrolyte levels and blood loss. The values of pH, base excess

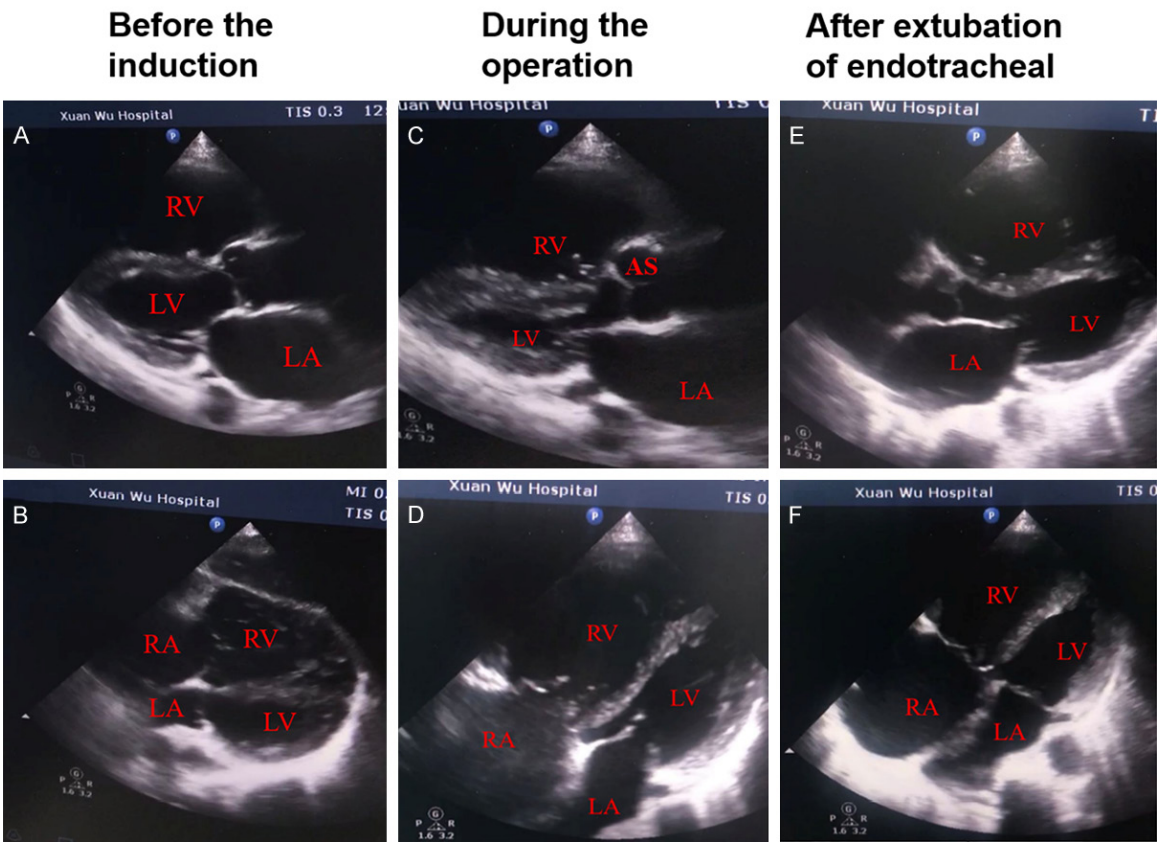

Figure 3. The long-axial views of the parasternal left ventricle are shown in images (A, C and E). The parasternal four-chamber views are shown in images (B, D and F). (A, B) Before the induction. (C, D) During the operation. (E, F) After extubation of the endotracheal tube. Left ventricle (LV), Right ventricle (RV), Left atrium (LA), Right atrium (RA), Aortic sinus (AS).

(BE), arterial partial pressure of carbon dioxide ($PaCO_2$) and arterial partial pressure of oxygen (PaO_2), and hemoglobin (HGB) concentration were all maintained in the normal range respectively.

Effect of surgery on hemodynamics: From the beginning of the operation to the placement of bone cement, the patient's vital signs were relatively stable, and his hemodynamic parameters fluctuated very little, with no decrease in CO. After the bone cement was implanted, there was an instantaneous drop in HR and blood pressure and the emergence of frequent premature ventricular beats, but no dramatic change in CO. At this time, we increased the infusion rate of dobutamine from 2-3 to 5-6 μg/kg/min and administered lidocaine 40 mg. The HR and BP rebounded gradually, and the number of premature ventricular beats also gradually decreased. The vital signs stabilized and remained stable until the end of the operation (**Figure 1A**).

*Perioperative dynamic monitoring of transthoracic echocardiography (TTE) (**Figure 3**):* These transthoracic echocardiographic images reflect typical images of pulmonary hypertension. The long-axial views of the parasternal left ventricle are shown in images A, C and E, reflecting the motor function of the left ventricle and mitral regurgitation. The parasternal four-chamber views are showed in images B. D and F, demonstrating the shape and volume changes of the atrioventricular cavities, as well as the regurgitation of mitral and tricuspid valves. Preoperative TTE showed that the right atrium and ventricle were enlarged, and even the interventricular septum had a slight left ventricular deviation. The volume of the left atrium and ventricle was decreased. The diastolic function of the left ventricle was decreased. Mild mitral regurgitation and moderate tricuspid regurgitation were found (**Figure 3A** and **3B**). Intraoperative TTE showed that under general anesthesia, the right ventricular volume did not contin-

ue to increase, the interventricular septum did not further shift to the left, and the left ventricular motor function was fair and did not appear significantly weakened compared with the preoperative state (**Figure 3C** and **3D**). After the infusion of narcotic drugs and vasoactive drugs was stopped and the tracheal tube was pulled out, the patient's TTE showed that the volume of each atrioventricular cavity and the left ventricular motor function did not show significant changes compared with the preoperative state (**Figure 3E** and **3F**).

The surgery duration was 100 min and the total anesthesia time was 211 min. The total intraoperative fluid supplement was 1900 ml, and the actual injection volume was 1500 ml, including 1400 ml crystalline liquid and 500 ml colloidal liquid; intraoperative blood loss and urine volume were 50 ml and 400 ml, respectively. The patient recovered after the operation without cough, nausea, or vomiting; extubation was performed and the patient was returned to the intensive care unit (ICU) with the arterial and central venous catheters in place.

Discussion

Despite advances in molecular biology, the pathogenesis of PH remains unclear [3]. PH may be due to the proliferation of pulmonary arteries and veins that leads to an increase in pulmonary vascular resistance (PVR), which eventually causes heart failure of the right side. In our case, the cause of severe pH (SPAP 103 mmHg) [4] was considered to be due to a long history of pulmonary embolism, which was initiated by deep venous thrombosis in the lower extremity.

Full evaluation and preparation before surgery is required to ensure the success of the operation and the safety of the patient. The patient with severe PH was fully evaluated before the operation to assess intraoperative risks including emboli detachment and pulmonary embolism, massive intraoperative bleeding, right side heart failure, and whole heart failure. A cardiologist was asked to make preoperative consultations with this patient to help evaluate the surgical risk and adjust the dosage of the cardiotonic agent digoxin, which is recommended to strengthen the intraoperative electrocardiographic monitoring. A vascular surgeon was asked to advise upon the continuation of anticoagulation if the patient's condition allowed. He advised us to adjust the oral dose of warfarin to maintain an INR of 1.8-2.5 and offered to review the intravenous ultrasound.

The anesthesia program was designed to keep pulmonary vascular resistance stable, maintain an appropriate CO level, and ensure the perfusion of vital organs, especially in elderly patients. The patient with PH underwent lumbar fusion and vertebroplasty under general anesthesia. The stability of the circulatory system during surgery is the goal of the anesthesiologist. Because PH itself can reduce CO and may induce mitral and tricuspid valve regurgitation, the HR and IBP should not fall below preoperative levels (thus ensuring the CO remains at preoperative levels) to avoid the occurrence of arrhythmia. The CO levels remained stable at 4.5-5 L/min throughout the operation, and were basically consistent with the preoperative levels. Although there were additional premature ventricular beats during the implantation of bone cement, which gradually disappeared after the sudden drop in blood pressure was corrected, there was no arrhythmia during the operation. The vertebroplasty was performed via direct injection of 4 ml of bone cement into the L3, L4, and L5 vertebral bodies, and the effect of vasodilation induced by the methyl methacrylate monomer in the vascular endothelium likely reduced the systemic vascular resistance and led to a transient drop in blood pressure [5]. As the patient's CO and CVP levels did not remarkably decrease and increase, respectively, at the time and the $PetCO_2$ and airway pressure did not obviously decrease and increase, respectively; therefore we ruled out fat embolism and designated the incident a pulmonary embolism caused by bone cement implantation. Indicators of SVV and CO were observed via Vigileo monitor to guide fluid management [6] and evaluation of cardiac function and allowed maintenance of the SVV values within the normal range (<13%) under general anesthesia. The goal-directed, fluid therapy strategy optimized the volume load in our patient and prevented complications such as heart failure and venous fluid retention. In addition, the depth of the anesthesia was guided by monitoring of the BIS data. The depth of the anesthesia should not be too low (below 30) for elderly patients, and the BIS should be maintained between 50±10 [7] to avoid an increase

in the incidence of delirium and the delay of postoperative recovery. The BIS value of the patient was between 47 and 60 during the operation and recovered smoothly to 87 within 15 min after the surgery with no adverse reactions such as pain, restlessness, choking, nausea, or vomiting. Intermittent and timely analysis of arterial blood gas ensured a normal acid-base balance and normal electrolyte levels (potassium and calcium). During surgery, the patient was in a state of slight hyperventilation as $PetCO_2$ was kept between 30-35 mmHg to avoid pulmonary vasoconstriction caused by hypercapnia. Considering the patient's advanced age and poor tolerance of anesthesia, we did not use nitroglycerin so as to avoid a sudden drop in blood pressure that would lead to insufficient organ perfusion. We used dobutamine and norepinephrine to maintain hemodynamic stability without the use of intraoperative pulmonary vasodilator therapy, such as a prostanoid infusion, during the operation. Additionally, we used mild hyperventilation in machine-controlled breathing with no PEEP for the patient to avoid an increase in pulmonary vascular resistance.

We did not implant a right side heart catheter into the patient, which is used to monitor pulmonary arterial pressure continuously [8], in order to avoid the formation of a new thrombus or shedding of the original embolus in the pulmonary artery. The trend of CVP was used and has a certain reference value for the evaluation of hemodynamic stability, pulmonary arterial pressure and cardiac function. The CVP was relatively stable throughout the procedure, except just before the endotracheal tube was removed. This sudden increase may have been due to increased sympathetic activity leading to pulmonary vasoconstriction before extubation, resulting in a sudden rise in pulmonary arterial pressure. The right ventricular function may not have been strong enough to overcome the severe PH that caused the sudden rise in the CVP. After the endotracheal tube was pulled out, the CVP decreased to 16-17 cm H_2O, which was close to the preoperative level.

Transthoracic echocardiography is the most important noninvasive method for screening for pulmonary hypertension. During the perioperative period, we dynamically monitored the transthoracic echocardiography of the patient. During and after the operation, we found that the volume of each atrioventricular cavity, especially the anteroposterior diameter of the right ventricle, and the motor function of the left ventricle did not change significantly compared with the preoperative state. Therefore, the anesthetic management including infusion of liquid and vasoactive drugs during the operation was considered to be reasonable.

Limitations

Due to the limited technical examination means, our hospital cannot carry out a ventilation-perfusion (V/Q) scan for Chronic thromboembolic PH (CTEPH) screening. In addition, the cardiologist did not recommend the surgical department to make a further definite diagnosis of the pH reported by echocardiography, and therefore the neurosurgeon did not do CT angiography for the patient before the operation. TTE only did dynamic monitoring of the patient's heart morphology, but did not make quantitative measurement. The diagnosis of PH and further examination of the patient have yet to be improved.

Conclusions

Adequate perioperative optimization, reasonable design of the anesthesia program, sufficient anesthetic sedation, analgesia, and antistress management, the use of intraoperative PH-targeted therapy, and a well-established multidisciplinary consultation ensured the success of the operation and the safety of the patient with severe PH, thus reducing the patient's risk of respiratory and cardiovascular complications. The successful anesthesia management of this case may provide important reference value for similar elderly patients in the future.

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Disclosure of conflict of interest

None.

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