Case Report

DOI: 10.6966/EDMJ.202309_10(3).0005

Predictive Values of Measuring Pulmonary Venous Pulsed-Waves during Acute Intraoperative Pulmonary Artery Embolism: A Case Report

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Acute intraoperative massive and bilateral pulmonary artery embolisms (PE's) are associated with extremely high mortality rates and should be diagnosed promptly in the operating room. In this case report, we will present a patient that developed an intraoperative PE where the extent of the embolism was assessed by measuring pulmonary venous flow velocity under transesophageal echocardiography (TEE).

Key words: intraoperation, pulmonary veins, pulse wave doppler

Introduction

The incidence of intraoperative acute pulmonary artery embolisms (PE) ranges from 0.3% to 30% based on previous observational studies.[1,2] The overall incidence of intraoperative PE in female patients undergoing gynecological surgery is about 1.6%, the incidence is significantly higher for patients undergoing surgery for ovarian cancer.[3] Other independent risk factors include patient age (> 65 years) and operation length (> 360 minutes).[3] Small and submassive intraoperative PE's are usually treated conservatively as the mortality rates are considerably lower (< 1% and 3% respectively).[4] However, the mortality rate of intraoperative massive and bilateral PE's can be extremely high (up to 25% – 65% mortality rate) and should be treated aggressively, including the use of interventional embolectomy and extracorporeal life support.[1,4] Therefore, it is important to have a prompt and reliable screening tool in theatres to quickly diagnosis and stratify the clinical risk of PE's to improve survival outcomes and facilitate early planning of acute treatment strategies. Here, we present a patient who developed an intraoperative PE during a gynecological procedure where the severity and extent of the embolism was quickly assessed by pulmonary venous flow velocity under transesophageal echocardiography (TEE).[3]

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Received: August 8, 2021 Accepted: November 4, 2021

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Case Report

A 42-year-old female undertook hysteroscopic surgery for hyperplastic endometrium and uterine polyp removal. The patient's medical history included hypertension, diabetes mellitus, and raised body mass index (BMI). The patient's hypertension and diabetes mellitus were well controlled with oral medications and her BMI was last measured at 30.1 kg/m^2. Her surgical history included a cesarean section performed a few years ago. The routine preoperative chest X-ray, electrocardiography (ECG), and blood tests, including the coagulation profile, did not show any significant abnormalities apart from the occasional premature ventricular contractions on ECG. There was no lower limb swelling and the patient denied oral contraceptive use. Abdominal sonography revealed a large mass in the uterus and both ovaries were normal. The patient was classed as the American Society of Anesthesiologists (ASA) physical status 2 preoperatively. The procedure was performed while the patient was in the lithotomy position and the patient was anesthetized using intravenous sedatives with no airway instrumentation. The operation took approximately 30 minutes and was uncomplicated. At the end of operation when the patient's legs were returned to the normal resting position, the patient suddenly became hypotensive (blood pressure dropped from 120/75 mmHg to 90/65 mmHg) and desaturated (SpO_2 dropped from 100% to 88%). The patient was immediately started on positive ventilation support via manual bagging through a face mask. However, her blood pressure remained low after an intravenous bolus of 0.02 mg norepinephrine and her SpO_2 remained below 90% despite 100% high-flow oxygen supplementation. The patient was paralyzed using loading dose of intravenous rocuronium (50 mg) and an endotracheal tube was placed for mechanical ventilatory support. Capnography showed low expiratory end-tidal CO_2 levels ($ETCO_2$) of about 20 – 25 mmHg. A central venous catheter was inserted and found an elevated mean pressure in the right internal jugular vein of up to 26 mmHg. A TEE was performed to assess cardiac function and diagnosis PE; the echocardiogram showed dilatation of the right cardiac chambers and leftward bowing of the interatrial septum (Fig. 1A). A floating thrombus was found in the right atrium (Fig. 1A & Video 1) which suggested that the patient has developed a thrombus-induced PE. The left and right pulmonary venous flow patterns were evaluated for pulmonary circulation blood flow return. Pulsed-wave doppler (PWD) showed normal anterograde systolic and diastolic flow patterns in the right upper and lower pulmonary veins, but the flow velocity was reduced in the left pulmonary veins. The patient was then given a bolus of 5,000 U intravenous heparin. About 15 minutes later, the thrombus in the right atrium dislodged, and the patient developed another episode of hypotension when the thrombus became undetectable on the echocardiogram (Fig. 1B). However, pulsed-waves in the right pulmonary veins remained normal (Fig. 1C) and venous flow waveforms in the left pulmonary veins flattened (Fig. 1D). After stabilizing the hemodynamics with an intravenous low-dose norepinephrine infusion (2 μg/min), the patient was transferred to the intensive care unit (ICU) for supportive care.

A contrast computed tomographic pulmonary angiography later confirmed a fixed thrombus in the left lower lobar pulmonary artery (Fig. 2A) and a patent right pulmonary artery trunk (Fig. 2B). A sonographic examination did not find any obvious thrombi in the deep veins of the lower limbs. Blood tests showed significantly elevated plasma D-dimer (35 μg/mL). The patient was started on a heparin infusion at a rate of 600 U/h for 48 hours and then switched to oral rivaroxaban (30 mg/d) to manage the thrombus. The patient was successfully extubated 24 hours after ICU

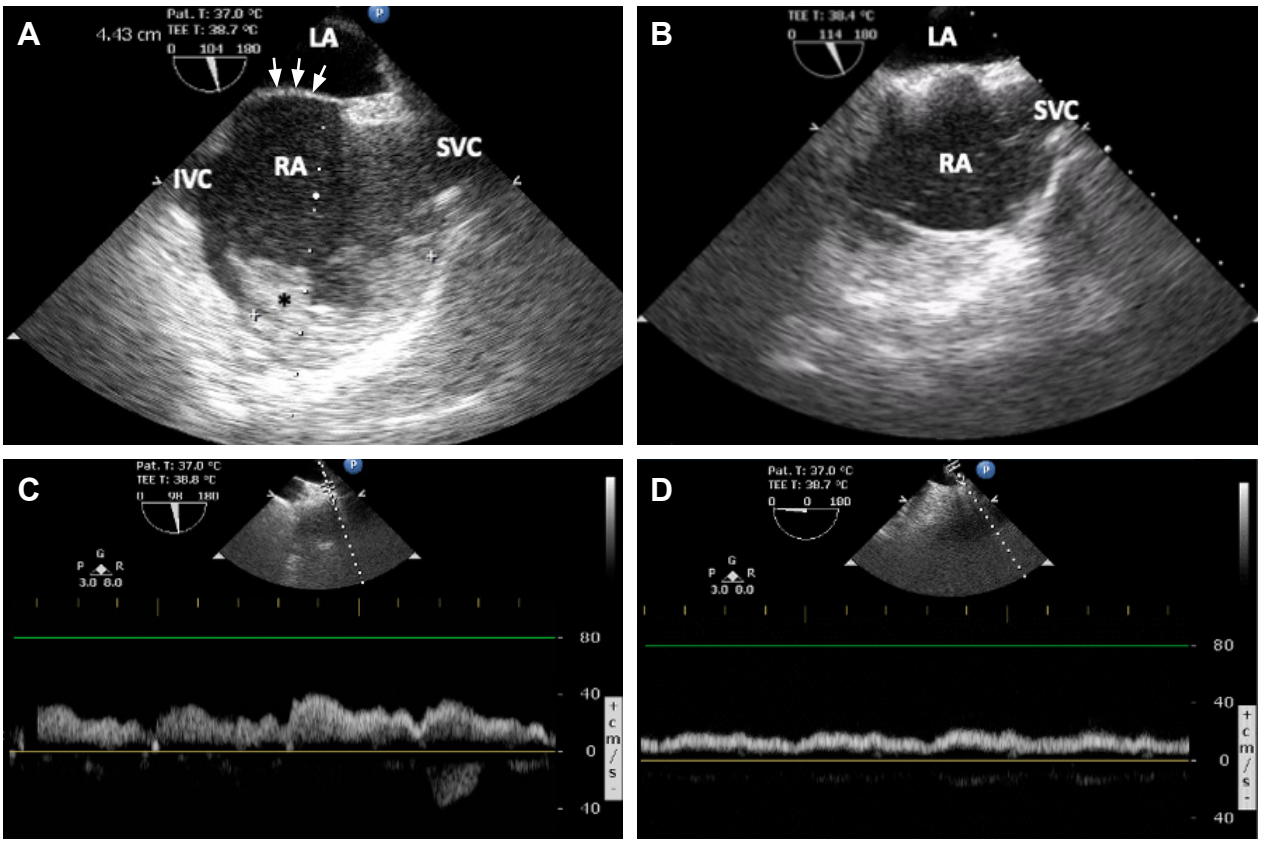


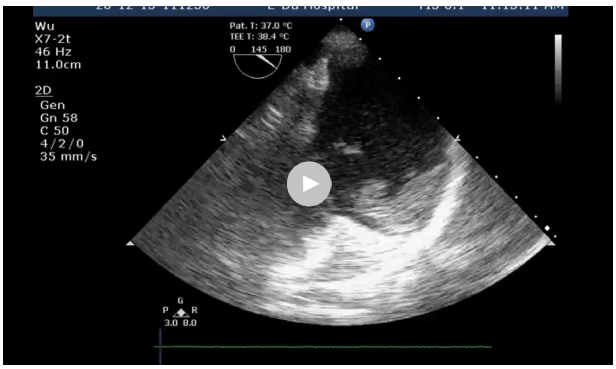
Fig. 1 (A) The bicaval view of transesophageal echocardiogram showed dilatation of right atrium (RA) and bulging of septal wall to the left atrium (LA) (arrows). A large thrombus (asterisk) of 4 cm in length was noted in the right atrium. (B) The RA thrombus was undetectable under echocardiography 15 min later and followed by another episode of hypotension. Pulsed-wave doppler measurement of flow velocity at the orifices of right upper pulmonary vein (C) and left upper pulmonary vein (D). The flow velocity was about 40 cm/s in the right pulmonary vein, but was almost diminished in the left pulmonary vein. IVC: inferior vena cava; SVC: superior vena cava.

admission and gained full recovery without any notable neurologic sequelae. She was discharged from the hospital two weeks later.

Discussion

Massive PE's are defined as an obstruction of more than 50% of the cross-sectional area of the pulmonary arterial circulation leading to severely reduced hemodynamic reserve, and subsequently, acute severe cardiopulmonary failure.[5,6] Patients who develop massive PE's have a high 1-hour mortality rate unless a rapid diagnosis is made and life-saving interventions are given.[5,7] A definitive diagnosis of PE can be made by computed tomographic angiography, conventional pulmonary angiography, lung scintigraphy, or echocardiography.[5] However, most of these diagnostic tools are not readily accessible in the operating room if an acute PE develops intraoperatively. In this situation, TEE can be a useful tool to quickly diagnosis and assess intraoperative PE's.[1] A previous comparison study found that TEE's had high sensitivity and specificity in diagnosing central PE's (80% and 100%, respectively).[8]

In the operating room, the diagnosis of acute intraoperative PE depends largely on the clinical presentations. Although our patient was anesthetized, she presented with the characteristic clinical signs of acute PE, including hypoxemia, hypotension, low $ETCO_2$, and elevated central venous pressure.[9] A TEE was performed within 20 minutes after the onset of symptoms and found a floating thrombus



Video 1. A floating thrombus in the right atrium.

(4 cm in length) in the right atrium with signs of pressure overload in the right cardiac chambers. PWD demonstrated normal flow velocity patterns in the right pulmonary veins but significantly depressed flow rates in the left pulmonary veins, suggesting that the obstruction was mainly confined to the left pulmonary artery that resulted in a reduction in blood flow draining from the left pulmonary circulation. Anticoagulation therapy with heparin was started immediately after the PE was confirmed on echocardiography. Unfortunately, the thrombus in the right atrium dislodged after heparin therapy which was followed by a second episode of hypotension and further diminishing of pulsed-waves in the left pulmonary vein. At this time point, the left pulmonary artery was almost completely occluded which was clinically comparable with massive PE. Since PWD waveforms in the right pulmonary veins remained normal and stable hemodynamics were restored following a low-dose norepinephrine infusion, our team, including cardiovascular surgeons and cardiologists, agreed to continue conservative treatment for this patient, as the PE was confined mainly to the left pulmonary artery and venous flow return was preserved in the right pulmonary circulation. Eventually, the patient recovered completely from the PE and was discharged home 2 weeks after the event.

In clinical practice, PWD echocardiography is commonly used to determine pulmonary vein flow in differentiating constrictive pericarditis, estimating left ventricle filling pressures, and evaluating the severity of mitral regurgitation.[10] Diminishment of pulsed-waves in the isolated pulmonary vein usually indicates absence of filling volume in the left atrium due to obstruction in the inflow of pulmonary artery. To our knowledge, there are no reports documenting the use of pulmonary vein pulsed-wave measurements to evaluate atrial inflow during acute PE. However, pulmonary venous PWD should be considered as a tool for quick assessment of the severity of intraoperative PE, but not to be used for diagnosis of PE.

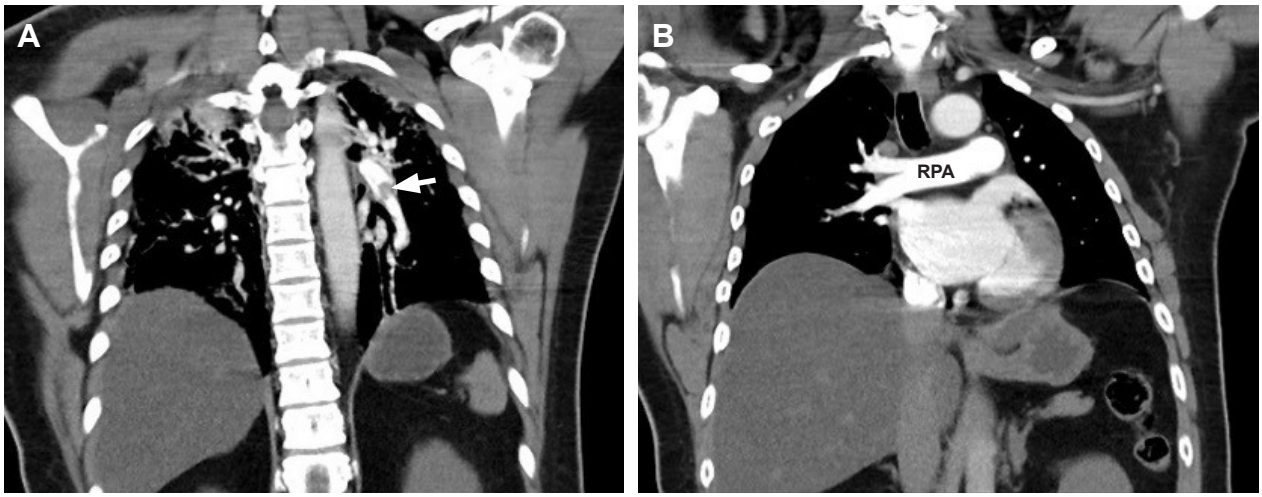


Fig. 2 (A) Spiral computed tomography of pulmonary arteries showed filling defects (arrow) in the left lower lobar and segmental pulmonary artery that was comparable with left pulmonary artery embolism. (B) No obvious radiographic lesions were found in the right pulmonary artery (RPA).

Conclusions

In this report, we found that TEE can be used to rapidly evaluate right cardiac chamber function and visualize intracardiac thrombi in intraoperative PE's. In addition, pulsed-waves measurements in the pulmonary veins can also provide additional information regarding the extent of obstruction in the pulmonary artery circulation which could be helpful in clinical decision making in the operating room.

Author Contributions

HYW involved in patient care and drafting the manuscript; MCW performed the transesophageal echocardiography and captures of images; YKS drafted the manuscript and prepared the figures. All authors read and approved the final manuscript.

Funding

This research received no external funding.

Institutional Review Board Statement

This report was approved by the Institutional Review Board of the E-Da Hospital, Taiwan.

Informed Consent Statement

A written informed consent was obtained from the patient for publication of this case report.

Data Availability Statement

All data and materials presented in the manuscript are freely available for non-commercial purposes. Other patient's clinical data are not available.

Acknowledgements

The authors thank Ms. Yun-Chi Chang for her assistance in the application of the Institutional Research Board approval for reporting this case.

Conflicts of Interest

The authors declare no conflict of interest.

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