Original Article

Suspected Pulmonary Embolism in the First 2,000 Incidents Reports of Perioperative and Anesthetic Adverse Events in Thailand (PAAd Thai) Study

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Background: Perioperative pulmonary embolism (PE) is a rare but life-threatening complication. The diagnosis remains challenging due to non-specific clinical presentations, which may vary from asymptomatic to cardiovascular collapse.

Objective: To describe the clinical presentation, diagnosis, and outcomes of the patients after suspected PE as well as to investigate the cause among Thai surgical population.

Materials and Methods: The authors conducted an observational study by retrospective analysis of the data from the Perioperative and Anesthetic Adverse Events in Thailand (PAAd Thai) study. All surgical patients under anesthesia in 22 participating hospitals between January 1 and December 31, 2015, were included. The incident reports of suspected PE were reviewed independently by three anesthesiologists. Data regarding patient characteristics, clinical manifestation, and other details were obtained from the standardized incident report forms. Descriptive statistics was used.

Results: Of the 2,000 incident reports, 16 patients were diagnosed with suspected PE. Cardiac arrest occurred in 11 cases (68.7%) and the overall mortality rate was 37.5% (6 of 16 patients). Most incidents were reported in orthopedic patients (10 cases, 62.5%) and caused by thrombosis (13 cases, 81.2%). Most of the incidents occurred intraoperatively (10 cases, 62.5%). The confirmatory imaging studies were investigated in eight cases (50%). To minimize the adverse outcomes, having more experience along with the help from experienced assistants and improved multidisciplinary support, were predominantly recommended. In addition, the most frequent suggested corrective strategies were implementation of appropriate clinical practice guideline and quality assurance activity.

Conclusion: Perioperative PE causes significant morbidity and mortality. The diagnosis remains difficult but early detection of suspicious clinical presentation and optimization of the treatment are crucial. Identification of high-risk patients, intraoperative vigilance, and effective interdepartmental communication should be considered to improve patient outcomes.

Keywords: Perioperative, adverse event, anesthesia, pulmonary embolism, thromboembolic, complication

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Pulmonary embolism (PE) is a potential cause of perioperative morbidity and mortality. Surgery increases the risk for the development of PE as patients are generally immobilized and, together with tissue trauma, can lead to coagulation, cascade activation, and acute inflammatory response. These components are consistent with Virchow's triad[1], which describes three contributing factors for thrombus formation. Thrombosis is the predominant etiology of PE, but it can originate from other causes, for instance, air, fat, or bone cement. The overall incidence of perioperative PE ranges from 0.06 to 30%[2-9], while

fatal PE accounted for 16.9% to 31%[8,10-12]. The highest incidences are among orthopedic and trauma surgery[13]. Other perioperative risk factors for PE include duration and type of surgery, anesthetic technique, and no thromboprophylaxis when indicated[13,14].

The diagnosis of PE during perioperative period remains challenging because clinical presentation may vary from asymptomatic to sudden cardiac arrest depending on patient factors, surgical conditions, and location of the emboli[15,16]. Moreover, the classic signs and symptoms in non-anesthetized patients might be masked by sedation or general anesthesia. In addition, the differential diagnosis for the cardiovascular instability accompanying PE is wide-ranging. Therefore, it is essential for the anesthesiologists to be aware of PE in the perioperative period when clinical findings are strongly suggested to provide prompt treatment and avoid undesirable complications.

In 2015, the Royal college of Anesthesiologists of Thailand (RCAT) endorsed a multicenter study of Perioperative and Anesthetic Adverse Events in Thailand (PAAd Thai)[17,18]. The present study was conducted as a part of PAAd Thai study aiming to specifically report the cause, severity, and clinical course of suspected PE. Furthermore, the authors also aimed to identify the contributory factors and the factors minimizing the incidents, as well as suggested corrective strategies in this large-scale study across Thailand.

Materials and Methods

The present retrospective analysis was a part of PAAd Thai study, which was conducted between January 1 and December 31, 2015. Twenty-two hospitals (8 university and 14 service-based hospitals) across Thailand were asked to participate and report the critical incidents on an anonymous and voluntary basis by anesthesia personnel. After receiving approval of each institutional ethics committee, the study was conducted with exempted inform consent. The perioperative adverse events of interests such as suspected pulmonary aspiration, esophageal intubation, oxygen desaturation, cardiac arrest within 24 hours, etc., during anesthesia and 24 hours after surgery were recorded in a standardized incident report form as soon as possible after the occurrence. Each critical incident of the first 2,000 incident reports was reviewed by the site manager of each institution before sending to the data management unit.

For the present study, all incident reports of suspected PE were retrieved and reviewed independently by three anesthesiologists for data collection and analysis. Any discrepancies in the reported information were discussed to obtain a consensus. The definition of suspected or confirmed PE must meet at least one of the following criteria:

- Clinical diagnosis by suggested clinical manifestations, for example, sudden dyspnea or tachypnea, decrease end-tidal CO_2, hypoxia or desaturation, alteration of consciousness, hemodynamic instability, combined with a clinical document referring to the event of suspected PE[13,15,16].
- Confirmatory diagnosis by computed tomography pulmonary angiography (CTPA), transthoracic echocardiography, transesophageal echocardiography, ventilation-perfusion (VQ) scan, spiral computed tomography (CT) scan, or autopsy[13,15,16].

Demographic data (such as age, gender, body weight, height, American Society of Anesthesiologists [ASA] physical status), anesthetic techniques and monitors, as well as types of surgery were recorded. Details of the critical incidents were also noted and extracted from the freehand narrative part of the incident report form. These included the timing and location at the detection, clinical manifestations, confirmatory investigations, treatment, along with patient outcomes at 24 hours and seven days after the adverse events. Contributing factors, factors minimizing incidents as well as suggested corrective strategies to avoid each incident of suspected PE were also collected. Descriptive statistics were used to summarize data, which were presented as frequency and percentage.

Results

There were 333,219 anesthetics in the participating hospitals according to the PAAd Thai database between January 1 and December 31, 2015. Among these, there were 17 incident reports of suspected PE, which were selected for this review. However, one case was excluded due to irrelevant diagnosis of the incident of interests. Therefore, 16 cases remained in the final analysis.

Among the 16 cases of suspected PE, three cases (18.7%), 12 cases (75.0%) and one case (6.3%) were of the ASA physical status of 2, 3, and 5, respectively. Most incidents were female (11 cases; 68.7%), elective surgery (14 cases; 87.5%), and the median age was 65 years (ranged from 32 to 83 years). There were 10 cases (62.5%), three cases (12.5%), and one case each (6.2%) in specialties of orthopedics, neurosurgery, general surgery, obstetric

surgery, and urosurgery, respectively. Eleven cases (68.7%) were under general anesthesia, while five cases (31.3%) were under regional anesthesia. Eight cases (50.0%) occurred in either university or service-based hospitals.

The etiology of suspected PE was considered as mainly thrombosis (13 cases, 81.25%). Venous air embolism (VAE) was suggested in two cases as the anesthesiologist noticed a pressurized empty intravenous (IV) solution bag with large air bubbles in the infusion tubing set. One case was observed during a rapid administration of peripheral IV fluid after spinal anesthesia for cesarean section. The other was detected over an aggressive infusion of IV fluid through central venous catheter during brain aneurysm clipping. Bone cement implantation syndrome (BCIS) was the cause suspected PE in one case as the patients unexpectedly lost his consciousness and developed cardiac arrest five minutes after bone cement implantation. The diagnosis was confirmed intraoperatively by echocardiography.

Most of the incidents occurred intraoperatively (10 cases, 62.5%). Sudden cardiac arrest attributable to suspected PE was found in seven cases during the maintenance phase of the anesthesia and four cases in the postoperative period. Other clinical presentations and associated events are described in Table 1.

The reported incidents of suspected PE were confirmed in ten cases (62.5%). Among these, the two cases of suspected pulmonary air embolism were also considered to be proven as air bubbles were directly observed in the IV infusion set along with the suspected clinical manifestations. Diagnostic tests were performed in the other eight cases. Echocardiography was the most frequently used assessment tool in the present study. The details of critical incidents and other types of investigation are demonstrated in Table 2 and 3.

Serious adverse outcomes within the first 24 hours included cardiac arrest (11 cases, 68.75%) and death (5 cases, 31.25%) as shown in Table 4. Apart from these, major physiologic changes as immediate complications were also reported in one case. The patient did not regain consciousness after the surgery and developed dyspnea, followed by markedly decreased oxygen saturation and hypotension. The electrocardiogram demonstrated ST depression in lead II and findings in the cranial computed tomography were consistent with ischemic stroke of the right middle cerebral artery territory. Regarding the long-term outcomes at seven days after the incident, complete recovery following suspected PE was found in six cases (37.5%). These included the two cases of suspected pulmonary air embolism, which only minor physiologic changes presented at the time of the event. The other four cases were considered to originate from thrombosis. Two of these suffered from cardiac arrest requiring cardiopulmonary resuscitation. One case was found during general anesthesia for open nephroureterectomy and the other was detected in the intensive care unit shortly following extubation after

Table 1. Details of suspected pulmonary embolism incidents and clinical manifestation (n=16)

Characteristics	Number of reports n (%)
Suspected cause of PE	
Thrombosis	12 (75.00)
Air	3 (18.75)
Bone cement	1 (6.25)
Phase when alerted	
Induction	1 (6.25)
Maintenance	9 (56.25)
Recovery	4 (25.00)
Post-recovery	2 (12.50)
Diagnostic studies	
Echocardiogram	8 (50.00)
CTPA	4 (25.00)
D-dimer	1 (6.25)
Autopsy	1 (6.25)
Location	
Operating room	10 (62.50)
Recovery room	4 (25.00)
Intensive care unit	1 (6.25)
Ward	1 (6.25)

Clinical manifestations	Intraoperative		Postoperative (n=6)
	Under GA (n=7)	Under RA (n=3)	
Hypoxia/decreased SpO_2	3	1	3
Decreased $ETCO_2$	4	N/A	1*
Hypotension	5	2	3
Petechiae	1	0	0
Alteration of consciousness	N/A	2	5
Tachypnea/dyspnea	N/A	2	2
Cardiac arrest	5	2	4

PE=pulmonary embolism; CTPA=computed tomography pulmonary angiography; SpO_2=pulse oximetry; $ETCO_2$=end-tidal carbon dioxide; GA=general anesthesia; RA=regional anesthesia; N/A=not applicable

* The patient was not extubated after the surgery

Table 2. Reported cases of suspected PE

Patient	Age (years)/sex	Operation	Technique	Phase at alerted	Investigation	24-hour outcomes	7-day outcomes
1	63/F	Right TKA	SAB	Recovery	• N/A	• Unplanned ICU admission • Minor Physiologic change	• Complete recovery
2	53/F	Posterior decompression with fixation L3-S1	GA	Recovery	• Chest X-ray • Echocardiogram • CTPA	• Unplanned ICU admission • Cardiac arrest	• Death at day 5
3	58/M	Left thoracotomy with repair aorta	GA	Induction	• N/A	• Minor physiologic change	• ↑ hospital stay (>7 days) • Complete recovery
4	65/F	Right hemiarthroplasty	GA	Recovery	• Echocardiogram	• Cardiac arrest • Death	• Death
5	65/M	Prophylactic internal fixation with cemented long PFNA of left femur	GA	Maintenance	• N/A	• Cancellation of surgery • Cardiac arrest • Death	• Death
6	87/M	ORIF with long PFNA of right femur	SAB	Maintenance	• Echocardiogram • CTPA	• Cancellation of surgery • Cardiac arrest	• Missing data
7	68/M	Laminectomy L3 to L5 with PDS L2 to L5	GA	Recovery	• Echocardiogram • CTPA • CT brain	• Ischemic stroke • Myocardial infarction	• ↑ ventilatory support (20 days) • ↑ hospital stay (>7 days) • Vegetative state
8*	50/F	Clipping intracranial aneurysm	GA	Maintenance	• N/A	• None	• Complete recovery
9	80/F	ORIF with acetabulum reconstruction with plate	GA	Maintenance	• N/A	• Cancellation of surgery • Cardiac arrest • Death	• Death
10	80/F	Moore's hemiarthroplasty	GA	Post-recovery	• N/A	• Cardiac arrest • Death	• Death

F=female; M=male; GA=general anesthesia; SAB=subarachnoid block; N/A=not available; TKA=total knee arthroplasty; L=lumbar level; S=sacral level; PFNA=proximal femoral nail antirotation; PDS=pedicular screw fixation; ORIF=open reduction and internal fixation; CTPA=computed tomography pulmonary angiography; ICU=intensive care unit

* Suspected PE caused by venous air embolism

Table 3. Reported cases of suspected PE

Patient	Age (years)/sex	Operation	Technique	Phase at alerted	Investigation	24-hour outcomes	7-day outcomes
11*	32/F	Caesarean section with tubal resection	SAB	Maintenance	• N/A	• Minor physiologic change	• Complete recovery
12	83/M	Open nephroureterectomy with appendectomy	GA	Maintenance	• Echocardiogram • CTPA	• Cardiac arrest	• ↑ ventilatory support (8 days) • ↑ hospital stay (>7 days) • Complete recovery
13#	74/F	Moore's hemiarthroplasty	SAB	Maintenance	• Echocardiogram	• Cardiac arrest • Unplanned ICU admission • Cancellation of surgery	• N/A (referral to another hospital)
14	54/F	Transoral odontoidectomy with posterior wiring C1-C2	GA	Recovery	• Echocardiogram • D-dimer (>4,000 mcg/litre)	• Cardiac arrest	• ↑ ventilatory support (7 days) • ↑ hospital stay (17 days) • Complete recovery
15	67/F	Open reduction and skeletal traction of right femur	GA	Maintenance	• N/A	• Cardiac arrest • Unplanned ICU admission • Cancellation of surgery	• ↑ ventilatory support (>7 days) • ↑ hospital stay (>7 days) • Toe gangrene in both feet requiring amputation • Re-operation at day 24
16	55/F	Explore lap for liposarcoma removal	GA	Maintenance	• Echocardiogram • Autopsy	• Death	• Death

F=female; M=male; GA=general anesthesia; SAB=subarachnoid block; N/A=not available; C=cervical level; CTPA=computed tomography pulmonary angiography; ICU=intensive care unit

* Suspected PE caused by venous air embolism, # Suspected PE caused by bone cement embolism

Table 4. Immediate and long-term outcomes (n=16)

Adverse outcomes	Number of reports n (%)
Immediate outcomes within 24 hours	
Cardiac arrest	11 (68.75)
Death	5 (31.25)
Cancellation of surgery	5 (31.25)
Unplanned ICU admission	4 (25.00)
Minor physiologic change	3 (18.75)
Major physiologic change	1 (6.25)
Long-term outcomes at 7 days	
Death	6 (37.50)
Complete recovery	6 (37.50)
Prolonged hospital stay (> 7 days)	5 (31.25)
Prolonged ventilatory support	4 (25.00)
Missing data	2 (12.50)
Others	3 (18.75)

ICU=intensive care unit

transoral odontoidectomy. Although both patients made a full recovery, they experienced prolonged ventilatory support and hospital stay. Fatal outcome was found in six cases (37.5%). Other serious long-term complications included prolonged ventilatory support as well as hospital stay, ischemic toes requiring amputation, re-operation, and vegetative state. Both immediate and long-term outcomes are presented in Table 4.

As for the perspectives on the contributing factors, the attending anesthesiologists regarded inexperience and emergency situations as the most attributable part of the incident. Therefore, considerations to minimize the suspected PE outcomes included having more self-experience along with the help from experienced assistants and influencing interdepartmental communication. Finally, for the suggested corrective strategies, implementation of appropriate clinical practice guideline, quality assurance activity, and improvement of supervision were principally considered.

Discussion

Perioperative pulmonary PE can lead to serious adverse events and fatal outcomes. The present study reported 16 cases of suspected PE from the first 2,000 incidents of the PAAd Thai study. Among these, thrombosis was considered as the main etiology. However, the confirmatory diagnosis was established in approximately half of all cases. The present study findings also demonstrated suspected PE as the cause of cardiac arrest in almost 70% and the mortality rate was about one third of all cases.

Previous studies described the incidence of perioperative PE varying from 0.06% to 30% depending on the type of surgery[2-9]. These findings are consistent with the authors' results as the highest rate was among orthopedic surgery. However, the reported incidence of suspected PE in the present study might be underestimated. This is probably due to the unspecific PE symptoms, making the diagnosis less likely to be recognized. Orthopedic patients are at high risk of developing PE, especially in hip and knee arthroplasty as well as surgery of fracture of lower extremity. The analysis of suspected PE in Thai AIMS reported 12 cases of suspected PE (0.6% of 1996 incident reports)[16]. Among these, four cases (33.33%) underwent orthopedic surgery. The authors' results demonstrated a higher proportion rate of 62.5% (10 cases) and most of them were diagnosed of fractures of the hip or femur.

Sakon et al reviewed the incidence of clinical PE in general surgery in Japan. Their study demonstrated that the overall incidence of PE was 0.33%[8]. However, the incidence was interestingly more in cancer surgery (1.6%). One possibility was due to longer operation time as the surgery was more extensive. Moreover, tissue factor and cancer procoagulant are produced by tumor cells, which predisposes hypercoagulable state in these patients. In the present study, the authors also found two cases of suspected PE in intra-abdominal surgery. Both patients were primarily diagnosed with malignancy.

Maintaining a high index of suspicion in the setting of risk factors remains crucial on timely diagnosis and management of PE. In the present study, the most suggestive symptoms in patients under regional anesthesia and postoperative period were loss of consciousness, hypotension, and dyspnea along with desaturation. These findings are compatible with the previous retrospective studies. Kürkciyan et al analyzed the clinical presentation and diagnosis in patient with cardiac arrest admitted to the emergency department after PE[19]. The most suggestive reported symptoms in their study were sudden dyspnea and syncope. In addition, Kim et al evaluated PE in the postoperative orthopedic patients using spiral CT scans[20]. The symptoms most frequently related to positive scans were shortness of breath and low oxygen saturation (SpO_2 <90%). Nevertheless, during general anesthesia, symptoms such as tachypnea or alteration of consciousness are

obscured by anesthetics and mechanical ventilation. Therefore, clinical findings, for instance, tachycardia, hypotension, elevated jugular venous pressure, and abrupt decrease in end-tidal CO_2, are more useful indicators. Signs of pulmonary hypertension including gallop rhythm at the left sternal border and loud pulmonic component of second heart sound may also be observed. However, the clinical course usually deteriorates rapidly. The presence of cardiovascular collapse is a reliable predictor of fatal outcome in patients with acute PE[10]. Thus, presumptive diagnosis should be determined before obtaining definitive imaging studies to initiate timely management.

There are several modalities of investigation available to establish or exclude the diagnosis of PE. However, these might not be feasible for hemodynamically unstable or anesthetize patients. In the present study, confirmatory diagnostic tests were performed in half of all cases. Of these, 75% were in the university hospital. The reason might be because university hospitals in Thailand carried more resources such as specialists, advanced imaging studies, as well as laboratory tests than serviced-based hospitals. Echocardiogram was the most preferred diagnostic tool in the present series. This could be because it was readily available and more convenient to be used in any locations. In the evaluation of acute PE, echocardiogram can demonstrate the evidence of right ventricular dysfunction. Apart from that, the more typical echocardiograph signs can also be revealed such as right heart thrombus, shortened pulmonary ejection, acceleration time, certain tricuspid regurgitation, or notably the McConnell's sign, which is the hypokinesis of right ventricular free wall with normal contraction of the apical segment[21,22]. At the same time, echocardiography can differentiate other possible causes, especially co-existing cardiac conditions in which unspecific signs and symptoms of acute PE can be seen. CTPA is the gold standard of diagnostic imaging to detect PE. Nevertheless, the patients must be hemodynamically stable enough to be transported[15]. It is also time consuming and not always available in every hospital. In the authors' report, 25% of all cases had a verified diagnosis of PE by CTPA and all of them were in university hospitals.

Fatal outcome is the deleterious complication following perioperative PE. In the present study, the mortality rate at 24 hours and seven days after the onset of suspected PE was 31.25% and 37.5%, respectively. All patients with fatal outcome suffered from cardiac arrest at the time of initial clinical presentation. The present study findings are comparable to the study among Japanese surgical patients, which reported the overall mortality rate of 31%[8]. Comfere et al demonstrated that the severity of acute PE affected the survival outcome. In patients undergoing non-cardiac surgery, the 30-day mortality following symptomatic PE was 25.3%[10]. Strong predictors included hemodynamic instability needing treatment at the onset of PE, conditions requiring the use of mechanical ventilation, and ICU admission. Obviously, those predictors indicated the severity of PE. Additionally, higher ASA physical status, longer operation time, and blood component transfusion were also significant risk factors associated with mortality[10]. The pulmonary embolism severity index (PESI) has been validated to assess the risk of death from PE ranging from 0.8% to 27%[23]. It has been shown to significantly correlate with the 30-day mortality rate for prediction of the patient prognosis. The score consists of 11 clinical variables (age older than 80 years, male gender, cancer, congestive heart failure, chronic lung disease, tachycardia more than 110 bpm, systolic blood pressure of less than 100 mmHg, respiratory rate of more than 30 per minute, body temperature of less than 36°C, altered mental status, and arterial oxygen saturation of less than 90%). Additional potential factors from other prior studies included the use of thromboprophylaxis[24]. However, in the present study, there were no documentations in the context of thromboembolic prevention. Therefore, identification of perioperative risk factors for fatal PE would be beneficial to the management plan, especially for the high-risk patients in whom more vigorous treatment are required. To that purpose, implementation of clinical practice guideline regarding prevention of venous thromboembolism and improved interdepartmental collaboration should be considered as valuable corrective strategies as suggested by the attending anesthesiologists.

VAE can also cause the clinical manifestations of pulmonary vascular obstruction. The etiology might be from surgical or anesthesia related. The latter included central venous catheterization, unrecognized epidural vein cannulation, the use of non-primed IV infusion set or pressure infusion bag. The morbidity and mortality depend on the volume of air entrainment and rate of accumulation[25]. If the volume is large, life-threatening effects on the cardiopulmonary as well as cerebrovascular systems will be presented. The air volume greater than 5 mL/kg can cause complete outflow obstruction of the right ventricle, leading to right-side heart failure and cardiovascular

collapse. The present study reported two cases of suspected PE from VAE, which resulted from rapid pressurized IV fluid infusion. These incidents are considered preventable; therefore, increased vigilance along with supervision are encouraged for primary minimizing factors.

BCIS is a potential cause of deleterious complication in patients undergoing cemented bone surgery. The incidence is highest among hemiarthroplasty[26]. The important clinical features include rapid hypoxia, hypotension, altered mental status, arrhythmia, or even cardiac arrest, in which occurs around the time of cementation. The severity of BCIS can be classified into three grades ranging from grade 1, moderate hypoxia and hypotension, to grade 3, cardiovascular collapse requiring cardiopulmonary resuscitation. The present study reported one case of confirmed PE with cardiac arrest caused by embolization from BCIS during Moore's hemiarthroplasty. However, the long-term outcome in this patient was missing because he was transferred to another hospital after returning of spontaneous circulation. The significant risk factors for developing severe BCIS are patients with pre-existing pulmonary hypertension or cardiac disease, male gender, diuretic use, pathological fracture, inter-trochanteric fracture, and long-stem arthroplasty[26,27]. Therefore, the Association of Anaesthetists of Great Britain and Ireland published the guideline for reducing the incidence of BCIS in cemented hip arthroplasty as follows: 1) identification of high-risk patients for cardiopulmonary compromise, 2) preparation of team and identification of roles in case of the severe reaction incident, and 3) intraoperative vigilance and effective communication between surgeons and anesthesiologists[27].

There are some limitations in the present study. Firstly, there was missing or incomplete information from the medical reports even if the site manager in each hospital collected and reviewed the data before sending the incident reports to the data management unit. Secondly, some minor incidents or outcomes might be underestimated since the difficult diagnosis of PE depends on a high index of suspicion and ruling out other possible conditions of the presenting clinical signs. Thirdly, because the resources for confirmatory tests are limited in some hospitals, the true incidence of perioperative PE remains uncertain. However, to minimize these problems, there were a great number of meetings and workshops before the participating hospitals became a part of this multicenter project, allowing them to be familiar with the definitions and the reporting system.

Conclusion

The incidence of perioperative suspected PE among Thai surgical patients is rare, but the mortality related to cardiac arrest is high. The etiology can be multifactorial. Presence of risk factors for PE combined with sudden change of consciousness and vital signs should lead anesthesiologists to be aware of this complication to initiate the timely management before obtaining diagnostic studies. The potential strategies for prevention of the incidence and minimizing the outcomes include implementation of the clinical practice guideline as well as the multidisciplinary planning and discussion.

What is already known on this topic?

Perioperative PE is difficult to diagnose only by clinical symptoms and could lead to detrimental outcomes. Among these, thrombosis is the common cause and orthopedic patients are at higher risk of developing PE.

What this study adds?

The present study demonstrated that confirmatory tests for investigation of PE were not readily available across Thailand. Therefore, presumptive clinical diagnosis was important for the prompt treatment. Preventable morbidity and mortality might be minimized by more experiences, having the help from experienced assistants, and improved multidisciplinary support. The recommended corrective strategies are the implementation of a clinical practice guideline and quality assurance activity.

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Conflicts of interest

The authors declare no conflict of interest.

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