The Thai Incident Monitoring Study (Thai AIMS) of Suspected Pulmonary Embolism: An Analysis of 1,996 Incident Reports

Tee Chularojmontri MD*, Intiporn Kositanurit MD**,
Somrat Charuluxananan MD***, Wimonrat Sriraj MD****,
Yodying Punjasawadwong MD*****, Aksorn Pulnitiporn MD******

** King Chulalongkorn Memorial Hospital and Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand*
*** Faculty of Medicine, Naresuan University, Phitsanulok, Thailand*
**** Faculty of Medicine, Chulalongkorn University and Chulalongkorn Research Center for Quality, Safety and Innovation in Patient Care, Bangkok, Thailand*
***** Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*
****** Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand*
******* Khon Kaen Regional Hospital, Khon Kaen, Thailand*

Background: *The present study is part of the multicenter study of model of anesthesia related adverse events in Thailand by Incident Report (The Thai Anesthesia Incident Monitoring Study or Thai AIMS). The objectives of the present study were to determine the frequency, clinical presenting, and outcomes of suspected pulmonary embolism.*
Material and Method: *The present study is a prospective descriptive research design. Three anesthesiologists extracted relevant data from the incident reports on suspected pulmonary embolism from the Thai AIMS database collected during the study period between January 1 and June 30, 2007. Descriptive statistics was used.*
Results: *After exclusion of four irrelevant or unlikely pulmonary embolism patients, there were 12 cases of suspected pulmonary embolism (0.6% of 1996 incident reports). Four cases (25%) were operated under emergency conditions. One incident (8.3%), eight incidents (67.7%), and three incidents (25%) were diagnosed by clinical diagnosis in preoperative, intra-operative, and 24-hour postoperative period. Common clinical manifestations were hypoxia (91.7%), hypotension (91.7%), and cardiac arrest (50%) at time of diagnosis. The mortality rate of obstetric surgery, orthopedic surgery, and general surgery were 42.8% (3 out of 7), 50% (2 out of 4), and 0% (0 out of 1 patient) with a total mortality rate of 41.7%. Only two patients (16.6%) that had incidental cardiac arrest survived. There were two cases (16.6%) of preventable incidents due to incorrect usage of pressure pump for rapid IV infusion.*
Conclusion: *Diagnosis of pulmonary embolism was difficult. The incidents were rare. Hypoxia and hypotension were the most common manifestations. Perioperative mortality rate was high (41.7%) despite prompt cardiopulmonary support. Most incidents were unexpected. An air embolism due to incorrect use of pressure pump for rapid IV infusion was considered preventable. Further epidemiologic studies for thromboembolism prophylaxis in Thailand are needed.*

Keywords: *Pulmonary embolism, Hypoxia, Hypotension, Cardiac arrest, Complications*

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Pulmonary embolism ranges from asymptomatic incidentally discovered emboli to massive pulmonary embolism causing severe hypotension and immediate death. The diagnosis and treatment of pulmonary embolism demand an interdisciplinary approach, combining surgical, medical, and radiologic specialties. Acute pulmonary embolism may occur unpredictably and be difficult to diagnose. Intra-operative pulmonary embolism is a rare but not infrequently reported event. The common cause of pulmonary embolism is venous thrombosis, many of the reported cases involved non-thrombotic material such as tumor cells[1-3], air[4,5], gas[6] and trophoblastic cells[7].

Correspondence to:
Charuluxananan S, Department of Anesthesiology, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.
Phone: 0-2256-4215
E-mail: somratcu@hotmail.com

In 2005, The Royal College of Anesthesiologists of Thailand (RCAT) endorsed a multicenter registry of anesthesia related adverse events among 20 hospitals across Thailand, the Thai Incidents Monitoring Study (THAI Study)[8,9]. The incidence of suspected pulmonary embolism in the perioperative period was 0.9%[9]. However, there is no sub-study describing pulmonary embolism reported.

In 2007, the RCAT in collaboration with the National Research Council of Thailand and the Thai Joint Commission on Hospital Accreditation, used the method of incident reporting to identify and analyze anesthesia related incidents in 51 hospitals, namely the Thai Anesthesia Incidents Monitoring Study (Thai AIMS)[10,11]. Pulmonary embolism was sporadically suspected as a peri-operative cause of death in Thailand. The objectives of this sub-study of the Thai AIMS were to determine natural course and factors related to suspected pulmonary embolism (PE).

Material and Method

The prospective multicenter study, the Thai Anesthesia Incidents Monitoring Study (Thai AIMS), was conducted by the RCAT between January 1 and June 30, 2007. All attending anesthesiologists and nurse anesthetists in 51 hospitals ranging from district (community) hospitals to tertiary (regional or university) hospitals across Thailand were invited to report the critical incidents on an anonymous and voluntary basis[10,11].

The present study was approved by all institutional ethical review boards, with no additional written informed consent required. The specific anesthesia adverse events detected during anesthesia and during the 24-hour postoperative period were reported by filling out a standardized incident reporting form as soon as possible after the occurrence of adverse events. These included pulmonary aspiration, suspected pulmonary embolism, esophageal intubation, endo-bronchial intubation, oxygen de-saturation, re-intubation, difficult intubation, failed intubation, total spinal anesthesia, awareness, cerebral-vascular accident, convulsion, nerve injuries, transfusion mismatch, suspected myocardial infarction/ischemia, cardiac arrest, death, suspected malignant hyperthermia, anaphylaxis, drug error, equipment malfunction, and cardiac arrhythmia requiring treatment. The surgical profile, anesthesia profiles, and a narrative of incidents were also recorded. Details of the Thai AIMS Study methodology have been described. All forms were sent to data management unit at Chulalongkorn University.

Each critical incident was reviewed by three anesthesiologists. Discrepancies among the three members were resolved by discussion. Grading of PE by peer reviewers was modified from Larach's grading of suspected malignant hyperthermia[12]. The descriptive statistics were used for data analysis with SPSS for Windows, version 12.0.

Results

During the six-month period between January and June 2007, sixteen suspected pulmonary embolism (PE) cases were reported. Patients were categorized into five grades by using clinical presenting factors (unexplained hypoxia, hypotension, and cardiac arrest), predisposing factors (pregnancy, aging, orthopedic surgery), and/or definite diagnosis by laboratory investigation (electrocardiography, chest x-ray and lungs scan). After review by three anesthesiologists, five grades of PE were classified among 16 initially suspected PE cases sent to the data management unit as shown in Table 1.

After exclusion of grade I patients from data analysis, there were 12 cases of suspected PE patients or 0.6% of 1996 incident reports. Age of patients ranged from 15 to 71 years, of which two cases (16.7%) occurred in patients whose age was more than 60 years. Most of the events occurred in patient weight between 50-82 kilograms and height between 150-185 centimeters. Three cases (25%) were male and nine cases (75%) were female. Seven cases (58.3%) had ASA physical status 1 and 2; five cases (41.7%) had ASA physical status 3 and 4. Four cases (25.0%) were operated under emergency condition. Among 12 incidents, one incident (8.3%), eight incidents (66.7%) and three incidents (25%) were diagnosed by clinical diagnosis in preoperative, intra-operative, and postoperative periods as shown in Table 2.

Table 1. Patient categorized by pulmonary embolism grading system (n = 16)

PE grading	n
Grade I: unlikely PE	4
Grade II: somewhat less than likely to be PE or cannot be excluded PE	3
Grade III: possible PE	1
Grade IV: somewhat greater than likely to be PE	4
Grade V: almost certainly PE	4

PE = pulmonary embolism

Eleven cases (91.7%), eleven cases (91.7%) and six cases (50%) experienced hypoxia, hypotension, and cardiac arrest, respectively, when diagnosis of pulmonary embolism were made. Characteristics of patient experienced pulmonary embolism are shown in Table 3. The mortality rate according to case characteristics is shown in Table 4. Two out of six patients (16.6%) that had cardiac arrest survived.

Table 2. Anesthetic and surgical characteristics of suspected pulmonary embolism patients

Characteristics	n (%)
ASA physical status	12
1	1 (8.3%)
2	6 (50%)
3	4 (33.3%)
4	1 (8.3%)
Emergency	4
Time of PE diagnosis	12
Preoperative	1
Intra-operative	8
Postoperative	3
Surgery/procedures	12
Obstetrics	7
Orthopedics	4
General	1

Discussion

Despite advances in medical technology, ruling out or diagnosis of pulmonary embolism (PE) remains one of medical problems in clinical practice[13]. PE is usually an under-estimated or under-diagnosed condition. Leibovitz et al reported that PE represented the main cause of death that is less suspected by healthcare provider, particularly in the elderly[14]. About 40% of PE found by autopsy in aging patients was not suspected during ante-mortem period[14]. The fact that pulmonary embolism is missed more often than it is diagnosed may be explained by the occurrence of non-specific signs and symptoms in the majority of patients. The lack of laboratory tests may be another major factor in the low incidence of antemortem diagnosis.

Table 3. Characteristics of patient experienced pulmonary embolism (n = 12)

No.	Age (yr)/sex	ASA	Preoperative conditions	Surgery	Anesthesia technique/drugs/position
1	23/F	2E	Pregnancy	Cesarean section, salpingooophorectomy	SA, bupivacaine in dextrose 12.5 mg/supine
2	27/F	4E	Pregnancy with presumptive amniotic embolism during labor pain	Cesarean section	GA/supine
3	25/F	2	Twins Pregnancy	Cesarean section	GA by a nurse anesthetist/ supine
4	29/F	2	Pregnancy	Cesarean section, tubal resection	SA/supine
5	32/F	3	Pregnancy, retained placenta, post MVR	Placental removal	GA/lithotomy
6	15/F	3E	Molar pregnancy	Suction evacuation of molar	GA/lithotomy
7	59/F	2	Ovarian cancer	Debulking tumors	GA/supine
8	71/M	3	Aging, post CABG	Hemiarthroplasty	GA/lateral decubitus
9	17/F	1		Plate and screw fixation of femur	SA, bupivacaine in dextrose 20 mg/supine
10	45/F	3E	DM, HT, trauma	Plate and screw of tibia	SA/supine
11	67/M	2	Aging	Decompressive laminectomy L5-S1 with fusion	GA/prone
12	29/M	2	AIDS	Exploration to drain TB ilium	SA/supine

* ASA PS = American Society of Anesthesiologists Physical status; F = female; M = male; E = emergency; MVR = mitral valve replacement; SA = spinal anesthesia; GA = general anesthesia; TB = tuberculosis

Table 3. Characteristics of patients with presumed pulmonary embolism (n = 12) (continued)

No.	Hypoxia	Hypotension/ rhythm at resuscitation	Onsite cardiac arrest, CPR	Associated events	Period at occurrence	PE grading	Outcome
1	Yes	Yes/bradycardia	Yes	Acute loss of conscious after coughing during placental delivery	Intra-operative	IV	Death (prolonged coma, persistent shock, ICU POD 1 dead)
2	Yes	Yes/tachycardia	No	Acute loss of conscious with severe hypoxia during per vaginal exam in LR, proceed to coagulopathy, DIC	Preoperative	V	Death ICU POD 0, hr 5
3	Yes	No/tachycardia	No	Periodic drop in SpO_2, Postop. crepitation both lungs	Intra-operative	II	Survived, exclude peripartum car diomyopathy EF 30-40%, D/C d 7
4	Yes	Yes/asystole	Yes	Postop hr 6, found arrest, may be respiratory depression	Postoperative	II	Death POD 0
5	Yes	Yes/bradycardia, PEA	Yes	Massive bleeding	Intra-operative	II	Survived
6	Yes	Yes/na	No	Rapid bleeding	Intra-operative	II	Survived
7	Yes	Yes /asystole	Yes	Enough, loss of conscious, hypoxia, arrest with seizure	Postoperative	IV	Death POD 1 ward
8	Yes	Yes/na	No	Acute hypoxia after coughing	Lung scan pulmonary infarction/ postoperative	V	Survived
9	No	Yes/na	No	High spinal to total spinal pressure bag pupm IV air	Intra-operative	V	Survived, complete recovery 45-60 min PACU
10	Yes	Yes/bradycardia, PEA	Yes	Leg elevation to bandage then acute loss of conscious	Intra-operative	IV	Death POD 0, hr 3
11	Yes	Yes/bradycardia	No	Sudden drop of $ETCO_2$ R/O with air embolism and ongoing bleeding from tear epidural vein	Intra-operative	III	Survived
12	Yes	Yes/pulseless VT+asystole	Yes	Acute loss of conscious, hypoxia. Pressure pump IV air embolism	Intra-operative	V	Survived, 30 min complete response to CPR

* ICU = intensive care unit; POD = postoperative day; PEA = pulseless electrical activity; LR = labor room; D/C = discharge from hospital, CABG =

In 2005, the RCAT reported the incidence of suspected PE in the THAI Study of which was also under-diagnosed[9]. Among 1,996 incident reports of the Thai AIMS, only 16 incident reports of suspected PE were sent to the data management center. After reviewing by 3 anesthesiologists, 4 patients of grade 1 (PE: unlikely) were excluded: 2 cases of suspected myocardial infarction, 1 case of severe hypotension after cementing of prosthesis and 1 case of bilateral lungs collapse. The remaining 12 cases of suspected PE (0.6% of total incident reports) were as follow: grade 2, or "somewhat less than likely" or "cannot be

Table 4. Mortality rates according to characteristics of suspected cases of pulmonary embolism

Characteristics	Total number	Fatal cases (n%)
Type of surgery		
Obstetric surgery	7	3 (42.8%)
Orthopedic surgery	4	2 (50.0%)
General surgery	1	0 (0%)
Clinical presentation		
Hypoxia	11	5 (45.5%)
Hypotension	11	5 (45.5%)
Cardiac arrest	6	4 (66.6%)
Grading for pulmonary embolism		
Grading II	3	1 (33.3%)
Grading IV	1	0 (0.0%)
Grading IV	3	3 (100%)
Grading V	4	1 (25%)
Period of events		
Preoperative	1	1 (100%)
Intra-operative	8	2 (25%)
Postoperative	2	2 (100%)
Total	12	5 (41.7%)

excluded" to be PE (4 cases: 33.3%), grade 3 or possible PE (1 case; 8.4%), grade 4, or "somewhat greater than likely" to be PE (3 cases; 25%) and grade 5, or "almost certainly" PE (4 case; 33.3%). The authors used clinical grading scale modified from Larach's grading scale to predict malignant hyperthermia, which was appropriate for diagnosis of such cases in Thailand where suspected PE patients were rarely diagnosed by sophisticated investigation such as perfusion lung scanning, computerized tomography or D-dimer enzyme-linked immune-sorbent assay (ELISA)[12]. The present study confirmed the reviews that diagnosis of PE is very difficult. Its incidence is rare. Suspected PE can occur with either male or female patients. One-third of the suspected PE cases occurred under emergency conditions whereas two-third (2 cases) occurred during the postoperative period. In the present series, suspected PE occurred commonly among obstetric and orthopedic surgical patients with sudden critical events.

All but one (91.7%) of all suspected PE cases experienced hypoxia (or oxygen desaturation) and severe hypotension. Half of the patients experienced cardiac arrest or received cardio-pulmonary resuscitation. In the present cases series, bradycardia occurred more frequently than tachycardia. Three patients (25%) were detected as pulseless or asystole while five patients (41.7%) developed sudden unconsciousness. Two cases developed sudden cough before unconsciousness.

The present study revealed that most of suspected PE occurrences happened spontaneously, and were thus not preventable. Two cases of preventable incidents were due to iatrogenic rapid infusing of air into the venous system by using pressure bag incorrectly. This should be the issue of focus among our community for developing preventive strategies.

The authors had one patient who was believed to have experienced non-fulminant bone cement implantation syndrome during hemi-arthroplasty. She experienced acute hypotension and bradycardia while cement was being implanted into her femur, followed by a loss of consciousness thereafter. After administration of vasopressor, she regained consciousnessand blood pressure returned to within a normal range. Embolic phenomenon has been proven to be the cause of bone cement implantation syndrome in animals and humans. The physiological consequences of emboli are considered to be results of both mechanical effect and mediator release, which provokes increased pulmonary vascular tone[15].

The signs of pulmonary embolism under anesthesia may be a temporary phenomenon, depending on the size of the embolus and the size of the pulmonary artery that is obstructed, as well as the number of emboli. Massive pulmonary embolism results in significant changes in cardiovascular and pulmonary function. This has been described in both the non-operative[16-18] and the intra-operative patient[19]. Classic findings include systemic hypotension, hypoxia, increased pulmonary dead space (resulting in hypercarbia and low $ETCO_2$), pulmonary hypertension, and increased central venous pressure. Hypoxia is a very common event during the evidence of pulmonary embolism. In acute pulmonary embolism, anatomic obstruction is undoubtedly the most important cause of compromised physiology, but the release of vasoactive and bronchoactive substance such as serotonin from platelets may lead to deterioration in ventilation-perfusion mismatching[20].

Previous studies have reported intra-operative presentation of pulmonary emboli with these systemic manifestations and have attributed them to the propagation of deep venous thrombi[20-30]. In many cases, symptoms began within minutes of manipulating the lower extremity. These manipulations included raising the limb to prepare the skin[25], placing

the patient in the prone position[31], inflation of a pneumatic tourniquet[30,32], release of a tourniquet[33] or exsanguination of the limb with an Esmarch bandage[26,28,29]. The common conclusion is that a thrombus was dislodged either by direct mechanical force applied to the clot or increased venous flow, resulting in propulsion of the clot.

Pulmonary embolism was more common in obese and elderly individuals. Prolonged illness, debility, immobilization in bed, and heart disease might be the predisposing factors. The presented patients also included pregnant and aging, which were risk factors. Women who are pregnant or in the postpartum period and women receiving hormonal therapy are all at increased risk for venous thromboembolism. Recent U.S. epidemiologic data showed a risk of venous thromboembolism among pregnant or postpartum women of 4.29, with an overall incidence of 199.7 cases per 100,000 woman-years[34]. Furthermore, the risk of a first episode of venous thromboembolism was five times as high in the postpartum period as during pregnancy, and the risk of pulmonary embolism was 15 times as high during the postpartum period as during pregnancy. Wells et al introduced Wells score to determine the possibility of diagnostic pulmonary embolism. It comprises of clinical suspected DVT (3 points), alternative diagnosis is less likely than PE (3 points), tachycardia > 100/min (1.5 points), immobilization/surgery in previous four weeks (1.5%) history of DVT or PE (1.5 points), hemoptysis (1.0 point) and malignancy (1 point)[35]. The traditional interpretation (4, 5, 10) is: Score > 6.0 - High (probability 59% based on pooled data); Score; 2.0 to 6.0 - Moderate (probability 29% based on pooled data) and Score < 2.0 - Low (probability 15% based on pooled data). If score > 4 than PE likely, consider diagnostic imaging, if score 4 or less –PE unlikely, consider D-dimer to rule out PE[35]. During the preoperative visit in risky patients, the authors should consider these factors. However, this protocol is not appropriate for the current situation in Thailand because of several limitations including laboratory test.

Pulmonary embolism causing hemodynamic instability is termed massive. Once it is suspected, a diagnostic plan and supportive measures are essential. The physiological effects of massive pulmonary embolism is such that resulting right ventricular failure may lead to compromised left ventricular preload, which may be life-threatening[36]. Vasopressor therapy should be considered early if the blood pressure is not rapidly restored. There is little information about the use of inotropic agents in general. Intubation, oxygen supplementation, and mechanical ventilation are instituted as necessary for respiratory failure[37].

The mortality rate of patients with suspected PE during 24 hour perioperative period was high (41.7%). Shock all presentation had an increased risk of mortality by a factor of three to seven. The majority of the deaths among patients with shock occur within the first hour of presentation[38]. In the authors previous study regarding cardiac arrest during anesthesia, suspected PE could not be ruled out[39-41].

The limitations of the present study are: (1) there were missing data due to incompleteness of data despite prospective data collection, (2) there was no definite diagnostic confirmation of PE in most cases. However, this is an important document about suspected PE in Thailand.

Conclusion

There were 12 out of 1996 incident reports of suspected PE in the database of the Thai AIMS with 41.7% mortality rate. Majority of suspected PE during 24-hour perioperative period cases occurred among, obstetric or orthopedic patients. Sudden hypoxia, hypotension, and unconsciousness were major clinical manifestations necessitating prompt cardiopulmonary support. Most of suspected PE during the 24-hour perioperative period were considered to be unexpected event and inevitable. However, there were two cases of preventable PE due to using a pressure bag for rapid IV infusion incorrectly. Further epidemiological studies regarding pulmonary embolism and thromboembolism in Thailand are needed.

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Potential conflict of interest

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References

1. Dorman F, Sumner E, Spitz L. Fatal intraoperative tumor embolism in a child with hepatoblastoma.

Anesthesiology 1985; 63: 692-3.
2. Sheridan M, Besser M. Fatal pulmonary embolism by tumor during resection of a choroid plexus papilloma: case report. Neurosurgery 1994; 34: 910-2.
3. Main BJ, Brown TC, Jones PG. Intraoperative pulmonary tumour embolism during hepatectomy. Can Anaesth Soc J 1984; 31: 117.
4. Wood SM, Roberts FL. Air embolism during transcervical resection of endometrium. BMJ 1990; 300: 945.
5. Cucchiara RF, Nugent M, Seward JB, Messick JM. Air embolism in upright neurosurgical patients: detection and localization by two-dimensional transesophageal echocardiography. Anesthesiology 1984; 60: 353-5.
6. Tsai SK, Lee TY, Mok MS. Gas embolism produced by hydrogen peroxide irrigation of an anal fistula during anesthesia. Anesthesiology 1985; 63: 316-7.
7. Hankins GD, Wendel GD, Snyder RR, Cunningham FG. Trophoblastic embolization during molar evacuation: central hemodynamic observations. Obstet Gynecol 1987; 69: 368-72.
8. Charuluxananan S, Suraseranivongse S, Punjasawadwong Y, Somboonviboon W, Nipitsukarn T, Sothikarnmanee T, et al. The Thai Anesthesia Incidents Study (THAI Study) of anesthetic outcomes: I. Description of methods and populations. J Med Assoc Thai 2005; 88 (Suppl 7): S1-13.
9. Charuluxananan S, Punjasawadwong Y, Suraseranivongse S, Srisawasdi S, Kyokong O, Chinachoti T, et al. The Thai Anesthesia Incidents Study (THAI Study) of anesthetic outcomes: II. Anesthetic profiles and adverse events. J Med Assoc Thai 2005; 88(Suppl 7): S14-29.
10. Punjasawadwong Y, Suraseranivongse S, Charuluxananan S, Jantorn P, Thienthong S, Chanchayanon T, et al. Multicentered study of model of anesthesia related adverse events in Thailand by incident report (the Thai Anesthesia Incident Monitoring Study): methodology. J Med Assoc Thai 2007; 90: 2529-37.
11. Charuluxananan S, Suraseranivongse S, Jantorn P, Sriraj W, Chanchayanon T, Tanudsintum S, et al. Multicentered study of model of anesthesia related adverse events in Thailand by incident report (The Thai Anesthesia Incidents Monitoring Study): results. J Med Assoc Thai 2008; 91: 1011-9.
12. Larach MG, Localio AR, Allen GC, Denborough MA, Ellis FR, Gronert GA, et al. A clinical grading scale to predict malignant hyperthermia susceptibility. Anesthesiology 1994; 80: 771-9.
13. Rogers RL. Venous thromboembolic disease in the elderly patient: atypical, subtle, and enigmatic. Clin Geriatr Med 2007; 23: 413-23.
14. Leibovitz A, Blumenfeld O, Baumoehl Y, Segal R, Habot B. Postmortem examinations in patients of a geriatric hospital. Aging (Milano) 2001; 13: 406-9.
15. Donaldson AJ, Thomson HE, Harper NJ, Kenny NW. Bone cement implantation syndrome. Br J Anaesth 2009; 102: 12-22.
16. McIntyre KM, Sasahara AA. The hemodynamic response to pulmonary embolism in patients without prior cardiopulmonary disease. Am J Cardiol 1971; 28: 288-94.
17. Huet Y, Lemaire F, Brun-Buisson C, Knaus WA, Teisseire B, Payen D, et al. Hypoxemia in acute pulmonary embolism. Chest 1985; 88: 829-36.
18. Moser KM. Pulmonary embolism. Am Rev Respir Dis 1977; 115: 829-52.
19. Mangano DT. Immediate hemodynamic and pulmonary changes following pulmonary thromboembolism. Anesthesiology 1980; 52: 173-5.
20. Elliott CG. Pulmonary physiology during pulmonary embolism. Chest 1992; 101(4 Suppl): 163S-71S.
21. Navalgund AA, Kang Y, Sarner JB, Jahr JS, Gieraerts R. Massive pulmonary thromboembolism during liver transplantation. Anesth Analg 1988; 67: 400-2.
22. Enright AC, Quartey GR, McQueen JD. Pulmonary embolism during operation. Can Anaesth Soc J 1980; 27: 65-7.
23. Hecker BR, Lynch C. Intraoperative diagnosis and treatment of massive pulmonary embolism complicating surgery on the abdominal aorta. Br J Anaesth 1983; 55: 689-91.
24. Goodman NW, Falkner MJ. Massive intraoperative pulmonary embolism in a child. Br J Anaesth 1987; 59: 1059-62.
25. Berry AJ. Pulmonary embolism during spinal anesthesia: angiographic diagnosis via a flow-directed pulmonary artery catheter. Anesthesiology 1982; 57: 57-9.
26. Samaan HA. Pulmonary embolism under general anaesthesia, following Esmarch bandage in injuries of lower limb. Anaesthesia 1970; 25: 445.
27. Hofmann AA, Wyatt RW. Fatal pulmonary embolism following tourniquet inflation. A case report. J Bone Joint Surg Am 1985; 67: 633-4.
28. Pollard BJ, Lovelock HA, Jones RM. Fatal pulmonary

embolism secondary to limb exsanguination. Anesthesiology 1983; 58: 373-4.
29. Estrera AS, King RP, Platt MR. Massive pulmonary embolism: a complication of the technique of tourniquet ischemia. J Trauma 1982; 22: 60-2.
30. Araki S, Uchiyama M. Fatal pulmonary embolism following tourniquet inflation. A case report. Acta Orthop Scand 1991; 62: 488.
31. Divekar VM, Kamdar BM, Pansare SN. Pulmonary embolism during anaesthesia: case report. Can Anaesth Soc J 1981; 28: 277-9.
32. Kato S, Okada K, Sakuramoto C, Okutomi T, Takenaka T, Goto F. [Fatal pulmonary embolism during knee surgery under epidural anesthesia]. Masui 1997; 46: 393-6.
33. Watanabe S, Terazawa K, Matoba K, Yamada N. An autopsy case of intraoperative death due to pulmonary fat embolism—possibly caused by release of tourniquet after multiple muscle-release and tenotomy of the bilateral lower limbs. Forensic Sci Int 2007; 171: 73-7.
34. Heit JA, Kobbervig CE, James AH, Petterson TM, Bailey KR, Melton LJ III. Trends in the incidence of venous thromboembolism during pregnancy or postpartum: a 30-year population-based study. Ann Intern Med 2005; 143: 697-706.
35. Wells PS, Anderson DR, Rodger M, Ginsberg JS, Kearon C, Gent M, et al. Derivation of a simple clinical model to categorize patients probability of pulmonary embolism: increasing the models utility with the SimpliRED D-dimer. Thromb Haemost 2000; 83: 416-20.
36. Dalen JE, Haynes FW, Hoppin FG Jr, Evan GL, Bhardwaj P, Dexter L. Cardiovascular responses to experimental pulmonary embolism. Am J Cardiol 1967; 20: 3-9.
37. Wood KE. Major pulmonary embolism: review of a pathophysiologic approach to the golden hour of hemodynamically significant pulmonary embolism. Chest 2002; 121: 877-905.
38. Alpert JS, Smith R, Carlson J, Ockene IS, Dexter L, Dalen JE. Mortality in patients treated for pulmonary embolism. JAMA 1976; 236: 1477-80.
39. Charuluxananan S, Thienthong S, Rungreungvanich M, Chanchayanon T, Chinachoti T, Kyokong O, et al. Cardiac arrest after spinal anesthesia in Thailand: a prospective multicenter registry of 40,271 anesthetics. Anesth Analg 2008; 107: 1735-41.
40. Kyokong O, Charuluxananan S, Werawatganon T. Risk factors of perioperative death at a university hospital I Thailand: a registry of 50,409 anesthetics. Asian Biomed 2008; 2: 51-8.
41. Charuluxananan S, Chinachoti T, Pulnitiporn A, Klanarong S, Rodanant O, Tanudsintum S. The Thai Anesthesia Incidents Study (THAI Study) of perioperative death: analysis of risk factors. J Med Assoc Thai 2005; 88(Suppl 7): S30-40.

การศึกษาเฝ้าระวังอุบัติการณ์ในสงสัยภาวะหลอดเลือดปอดอุดกั้น: การวิเคราะห์จากรายงานอุบัติการณ์ 1,996 ฉบับ

ธีร์ จุฬาโรจน์มนตรี, อินธิพร โฆษิตานุฤทธิ์, สมรัตน์ จารุลักษณานันท์, วิมลรัตน์ ศรีราช, ยอดยิ่ง ปัญจสวัสดิ์วงศ์, อักษร พูลนิติพร

ภูมิหลัง: *การศึกษาจากการเป็นส่วนหนึ่งของงานวิจัยสหสถาบันในโครงการศึกษาแบบจำลองของการเกิดภาวะแทรกซ้อนทางวิสัญญีในประเทศไทย โดยการรายงานอุบัติการณ์ (Thai AIMS) วัตถุประสงค์ของการศึกษานี้เพื่อทราบความถี่ อาการทางคลินิก และผลลัพธ์ของผู้ป่วยที่สงสัยภาวะหลอดเลือดปอดอุดกั้น*

วัสดุและวิธีการ: *เป็นการศึกษาแบบพรรณนาชนิดไปข้างหน้า วิสัญญีแพทย์ 3 คน วิเคราะห์ข้อมูลของรายงานอุบัติการณ์ของผู้ป่วยที่ได้รับการวินิจฉัยสงสัยภาวะหลอดเลือดปอดอุดกั้นจากฐานข้อมูล Thai AIMS ซึ่งเก็บข้อมูลรายงานอุบัติการณ์ระหว่างวันที่ 1 มกราคม พ.ศ. 2550 ถึง 30 มิถุนายน พ.ศ. 2550 วิเคราะห์ด้วยสถิติแบบพรรณนา*

ผลการศึกษา: *หลังจากคัดผู้ป่วย 4 ราย ซึ่งไม่ใช่ภาวะหลอดเลือดปอดอุดกั้นออก มีผู้ได้รับการวินิจฉัยสงสัยภาวะหลอดเลือดปอดอุดกั้น 12 ราย (ร้อยละ 0.6 ของรายงานอุบัติการณ์ทั้งหมด 1,996 รายงาน) 4 ราย (25%) เป็นผู้ป่วยที่ได้รับการผ่าตัดฉุกเฉิน 1 ราย (ร้อยละ 8.3), 8 ราย (ร้อยละ 67.7) และ 3 ราย (ร้อยละ 25) ของอุบัติการณ์เกิดขึ้นในช่วงก่อน, ระหว่างและช่วงหลังผ่าตัด 24 ชั่วโมง ร้อยละ 91.7, ร้อยละ 91.7 และร้อยละ 50 เกิดภาวะขาดออกซิเจน ความดันเลือดต่ำ และภาวะหัวใจหยุดเต้น อัตราเสียชีวิตในผู้ป่วยสูติกรรม ศัลยกรรมออร์โธปิดิกส์ และศัลยกรรมทั่วไปเท่ากับร้อยละ 42.8 (3 ใน 7 ราย), ร้อยละ 50 (2 ใน 4 ราย) และร้อยละ 0 (0 จาก 1 ราย) ตามลำดับ โดยมีอัตราการเสียชีวิตโดยรวมเท่ากับร้อยละ 41.7 ผู้ป่วยเพียง 2 ราย (16.6%) ที่เกิดภาวะหัวใจหยุดเต้นขณะเกิดอุบัติการณ์รอดชีวิต มี 2 อุบัติการณ์ที่สามารถป้องกันได้ ซึ่งเกิดจากการใช้เครื่องบีบอัดถุงบรรจุสารน้ำเพื่อให้สารน้ำเข้าหลอดเลือดอย่างรวดเร็ว*

สรุป: *การวินิจฉัยภาวะสงสัยหลอดเลือดปอดอุดกั้นทำได้ยากโดยอุบัติการณ์เกิดได้ไม่บ่อย อาการที่พบบ่อยที่สุดได้แก่ภาวะขาดออกซิเจนและภาวะความดันเลือดต่ำ อัตราการเสียชีวิตของภาวะสงสัยหลอดเลือดปอดอุดกั้นช่วงระหว่างและหลังการผ่าตัดสูงทั้งที่ได้รับการรักษาโดยทันที อุบัติการณ์ส่วนใหญ่เกิดขึ้นโดยไม่คาดฝัน การป้องกันที่แนะนำได้แก่ การป้องกันการเกิดภาวะอากาศอุดกั้นหลอดเลือดปอดจากการใช้เครื่องบีบ อัดถุงบรรจุสารน้ำ เพื่อให้สารน้ำอย่างรวดเร็วและการศึกษาทางระบาดวิทยา เพื่อสนับสนุนการป้องกันภาวะลิ่มเลือดอุดกั้นในประเทศไทย*