Perioperative Myocardial Ischemia / Infarction: Study of Incidents from Thai Anesthesia Incidence Study (THAI Study) of 163,403 Cases

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Objectives: *To analyze incidence, risk factors, clinical course, outcomes of PMI. Degree of anesthesia related to PMI, management, precipitating factors and corrective strategies.*
Material and Method: *PMI cases were extracted from the Thai Anesthesia Incidents Study (THAI Study) database conducted between February 1,2003 and January 31,2004, and analyzed using descriptive statistics.*
Results: *Forty-five cases were recorded as PMI (Suspected myocardial ischemia/infarction) from 20 hospital study centers. The incidence was 2.7:10,000 of all anesthetic services (163,403 cases). PMI occurred more frequently in male, underlying disease of hypertension, diabetes mellitus, ischemic heart disease, ASA class >2, under general anesthesia and during operation. EKG change and hypotension were primary clinical symptoms. PMI caused high mortality (5 cases), high morbidity (6 cases of brain death), high medical cost and change of management plan.*
Conclusion: *PMI was strongly impact to both anesthetic and surgical outcomes. Improve quality of anesthetic care for patient at risk and surgical risk reflected the whole anesthetic quality of care.*

Keywords : *Myocardial ischemia, Myocardial infarction, Anesthesia, Complication, Adverse events*

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Cardiovascular disease is a major health-care problem in every country in the world. Although hypertension is the most prevalent form of cardiovascular disease, coronary artery disease causes the highest morbidity (myocardial ischemia or infarction and congestive heart failure) and mortality (highest annually cause of death)[1]. Nowadays, the prevalence of patients with known and unknown cardiovascular disease required non-cardiac operation have been increasing. All methods for prospective evaluation of cardiac risk index [2-5] were introduced in routinely anesthesia practice to reduce the incidence and severity of perioperative adverse cardiac events which directly increased medical intervention, length of stay and cost of medical care. Occurrences of perioperative myocardial ischemia and infarction (PMI) were commonly followed by other serious adverse events and posed a strong impact on both anesthesia and surgical outcomes.

Incidence of PMI was 2.7:10,000 of all anesthetic services according to the Thai Anesthesia Incidents Study (THAI Study)[6,7]. We examined the association between patient characteristics, underlying diseases, cardiac risk index, and outcomes of PMI. We analyzed the impact of anesthesia related contributing factors and suggested some corrective strategies to improve anesthesia outcomes.

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Material and Method

The Thai Anesthesia Incidents Study (THAI Study) is a multi-centered study including seven university hospitals, five tertiary care hospitals, four secondary hospitals and four district hospitals across Thailand. We had monitored perioperative adverse events from 1 February 2003 to 31 January 2004.The study was approved by all institutional ethical review board. Details of preanesthetic conditions, anesthetic management, intra- and perioperative adverse events of consecutive patients within 24 hours were recorded on a standardized form (form 1) by protocol of registry study.

Myocardial ischemia or infarction was suspected when new ST-segment change (both elevation and depression) happened together with hypotension which could not be explained by other causes or elevation of cardiac enzymes or nitroglycerin was started for coronary effect during operation or other strong objective such as autopsy, echocardiography or coronary angiography.

Every case was followed up by attending anesthesiologist, nurse anesthetist or site manager until the patient was discharged from hospital or 30 days after the occurrence of PMI. All details of medical management were completed by site manager in standardized form for suspected PMI (form 2). Three peer reviewers were used to analyze and identify clinical risk factors, contributing factors and corrective strategies. All controversies were discussed to achieve a consensus.

All data were coded and recorded in SPSS 11.5 and analysed by using descriptive statistics. Analysis of incidence and subgroup incidence analysis were based on data of THAI Study.

Results

Forty-five patients were reported of suspected perioperative myocardial ischemia or infarction (PMI) in THAI Study which included 163,403 cases of anesthetic care. The incidence was 2.7:10,000 of all cases. The incidence was increased (Table 1) according to American Society of Anesthesiologists classification of physical status (ASA). The incidence was three times stepped up from 3.4:10,000 to 11-12:10,000 when ASA physical status increased from class 2 to 3 or 4.

Suspected PMI occurred more frequently during general anesthesia than spinal block and combined technique of general anesthesia with other regional anesthesia (3.8: 10,000 VS 1.1-1.3: 10,000). The incidences of PMI were also varied from center to center (Table 1), both between group of hospitals and each individual center. The incidence was 3.4:10,000 when data were pooled from university hospital (n=32 cases) and were varied from 2.1 to 5.6:10,000. This variation was high in tertiary and secondary care hospital. The incidence was 1.9:10,000 but variation was ranged from 0 to 50.3:10,000.

Male patients developed PMI more frequently than female (6:4), age varied from 42 to 89 year with mean $\pm$ SD of 65.2 $\pm$ 11.2 year. PMI was occurred in every cardiac risk (Table 2). Seventy percent were grouped in intermediate and high cardiac risk index. Only two cases had no underlying disease or condition. Others had one to seven underlying diseases or conditions. The three most common underlying diseases were hypertension (57.8%), ischemic heart disease (35.6%) and diabetes mellitus (26.7%). Half of cases were already preoperative cardiac evaluated by cardiologist.

Suspected PMI occurred mostly during operations (Table 2). Two cases occurred before induction of anesthesia and one case of severe hypotension and EKG change after administration of anesthetic induction agents. The operations were withhold in these three cases. The other twenty-one cases (51.2%) occurred in postoperative period. Nine cases occurred in recovery room with primary symptom of dyspnea, restlessness and hypotension. Only five from nine cases that complained of typical chest pain.

All nineteen cases that suspected PMI occurred more than two hours after operation complained of typical chest pain and two of them followed shortly by sudden cardiac arrest with unsuccessful resuscitation. Autopsy of both cases confirmed acute anterior myocardial wall infarction on top of old infero-lateral wall infarction.

The two most common clinical signs were EKG change (77.8%) and hypotension (77.8%). Chest pain and dyspnea were primary clinical symptoms only in postoperative period.

Both anesthesia (71.1%) and surgery (48.8%) were judged as precipitating factors of PMI. The events could be classified in categories which were: could be prevented in seventeen cases (37.8%), may be prevented in twenty two cases (48.9%) and could not prevent in six cases (13%). Only 35 cases of PMI that confirmed of myocardial infarction by typical EKG change and positive serum troponin-T elevation (16 cases) or others (2 cases by autopsy, fifteen cases from prolonged unstable hemodynamic, 2 cases by cardiac angiography and 2 cases by echocardiography).

Table 1. Demographic characteristics and anesthetic profiles (n=45)

		Number	%	Ratio:10,000
Gender	Male: Female	27 : 18		
Age (yr)	Range	42 — 89		
	Mean ± SD	65.2 ± 11.2		
Height (cm)	Range	140 — 178		
	Mean ± SD	162.2 ± 9.1		
ASA	Class 1 (n = 81,820)	1	2.2	0.1
	Class 2 (n = 58,487)	20	44.4	3.4
	Class 3 (n = 17,248)	19	42.2	11.0
	Class 4 (n = 3,210)	4	8.9	12.5
	Class 5 (n = 370)	1	2.2	27.0
Official time : yes		30	66.7	
Anesthetic technique, n (% of case)				
	General anesthesia	38	84.5	3.8
	Spinal block	5	11.1	1.3
	Combined technique	1	2.2	1.1
	Local infiltration	1	2.2	
Center code				
UH 001 (n = 9,587)		2	4.4	2.1
UH 002 (n = 15,283)		4	8.9	2.6
UH 003 (n = 13,341)		4	8.9	3.0
UH 004 (n = 7,383)		0	0	
UH 005 (n = 15,252)		4	8.9	2.6
UH 006 (n = 28,395)		16	35.6	5.6
UH 007 (n = 9,598)		2	4.4	2.1
TH 008 (n = 7,311)		0	0	
TH 009 (n = 13,880)		3	6.7	2.2
TH 010 (n = 11,006)		1	2.2	0.9
TH 011 (n = 10,929)		2	4.4	1.8
TH 012 (n = 1,193)		6	13.3	50.3
SH 013 (n = 5,892)		0	0	
DH 014 (n = 355)		0	0	
DH 015 (n = 545)		0	0	
SH 016 (n = 4,899)		0	0	
DH 017 (n = 125)		0	0	
DH 018 (n = 877)		0	0	
SH 019 (n = 5,338)		0	0	
SH 020 (n = 2,214)		1	2.2	4.5
Over all incidence (n = 163,403)		45	100.0	2.7

UH = University Hospital, TH = Tertiary care Hospital, SH = Secondary care Hospital, DH = District Hospital
Value shown as number, ratio : 10000, percent, range and mean ± SD

Suspected PMI caused severe physiological damage (Table 3) included five death (mortality rate of 11.12%) and six permanent brain damage (13.3%). Both outcomes were category of serious adverse outcomes. Only 34 cases were complete recovery. Every case needed to change the management plan which included 6.7% of postponement, 35.6% of unplanned ICU admission, 40% of prolong ventilatory support, 48.9% of prolong intensive care and 55.6 % of prolong hospital stay.

Human factors were analyzed as most common contributing factors (Table 4) which included decision failure in 77.8%, limited knowledge 42.2%, inexperience 75.6% and poor communication 26.7%. Emergency situations and inadequate patient preparations were coded as contributing factors in 22.2% and 55.6% respectively.

Additional training (80%), improved super-

Table 2. Underlying disease, cardiac risk, details of events (n=45)

	Number	% of cases
Cardiac risk stratified		
Low	13	28.9
Intermediate	24	53.3
High	8	17.8
Underlying disease		
No	2	4.4
Diabetes mellitus	17	37.8
Hypertension	26	57.8
Ischemic heart disease	16	35.6
Unstable angina	6	13.3
Post CABG	3	6.7
Anatomical heart disease	1	2.2
COPD	4	8.9
Respiratory failure	6	13.3
Sepsis	5	11.1
Electrolyte imbalance	4	8.9
Renal impairment	7	15.5
Old CVA	3	6.7
Shock	2	4.4
Other	5	11.1
Cardiologist consultation : yes	22	48.9
Drug usage before operation		
Isordil	14	31.1
Antihypertensive agents	19	42.2
Event occurrence, n (% of cases)		
Pre induction	2	4.4
Intra-operative	20	44.4
Within 2 hour after operative	9	20.0
Postoperative > 2 hour	14	31.2
Primary symptoms/sign		
Chest pain	19	42.2
EKG change	35	77.8
Hypotension	35	77.8
Dyspnea	12	26.7
Precipitating risk from		
Anesthesia	32	71.1
Surgery	22	48.8
Patient	10	22.2
Preventability		
Yes	17	37.8
May be	22	48.9
No	6	13.3
Confirm diagnosis of myocardial infarction		
Yes	35	77.8
EKG change and other	35	77.8
Positive trop T	18	40.0
Autopsy	2	4.4

Value shown as number and percent

Table 3. Outcomes and management effect (n=45)

	Number	% of cases
Immediate outcome		
Minor physiological change	10	22.3
Major physiological change	33	73.3
Cardiac arrest	1	2.2
Death	1	2.2
Final outcome		
Complete recovery	34	75.6
Permanent damage	6	13.3
Death	5	11.1
Management effect		
Postponement	3	6.7
Unplanned ICU admission	16	35.6
Prolonged ventilatory support	18	40.0
Prolonged intensive care	22	48.9
Prolonged hospital stay	25	55.6

Value shown as number and percent

Table 4. Contributing factors and corrective strategies (n=45)

	Number	% of cases
Contributing factors		
Human factors		
Decision failure	35	77.8
Limited knowledge	19	42.2
Inexperience	34	75.6
Careless	5	11.1
Fatigue	1	2.2
Poor communication	12	26.7
Emergency situation	10	22.2
Inadequate preparation	25	55.6
Equipment malfunction	3	6.7
Corrective strategies		
Additional training	36	80.0
Improved supervision	28	62.2
Guidelines practice		
Quality assurance activity	25	55.6
Good referral	5	11.1

Value shown as number and percent

vision (62.2%) and quality assurance activity (55.6%) were suggested as corrective strategies to reduce the incidence of PMI and improve the outcomes.

Discussion

The Thai Anesthesia Incidents Study (THAI Study) was the first large scale study of perioperative anesthetic related adverse events in Thailand. We registered every anesthetic services in twenty hospitals in phase I and finished with 163,403 cases[6,7]. The study included all anesthetic techniques provided for all surgical, diagnostic and non-surgical procedures. The in-

cidence of PMI (2.7:10,000 or 0.0027%) from this study represent PMI of all anesthetic services and the incidence was changed to 2.8:10,000 if all cardiac operations were excluded. This incidence was much higher than the prospective survey in France (during 1978-1982) of 198,103 anesthetic performed in 460 institutes[8]. They reported seven cases of myocardial infarction (0.35:10,000). But they also reported 16 cases of acute pulmonary edema and 18 cases of severe dysrhythmia[8].

Identification of PMI cases needed both regular adverse event reporting system and analysis cause of each event. From large scale systematic perioperative data collection [8-10] of anesthetic adverse events, the term of myocardial ischemia or myocardial infarction were put into the same list of physiological problems such as severe dysrhythmia, acute pulmonary edema or cardiac arrest and still lack of definite cause of each event. If all these events and definite cause were counted as severe perioperative cardiac events, the incidence were varied between1-4:10,000 of all anesthetic services and our incidence was in the same range with others.

Even this study listed term of myocardial ischemia or myocardial infarction as one objective data collection. Each study center was not consistency in identification of suspected PMI case and the incidences were varied in wide range. Even between groups of university hospital (code 001 to 007), the incidences were varied from 0 to 5.6:10,000. We concluded that the incidence of 2.7:10,000 of this study was lower than the actual incidence due to under reported cases. We recommended that every unexplained unstable hemodynamic in perioperative period should be investigated of myocardial ischemia, injury and infarction [9-12]. Serial EKG and specific cardiac enzyme study should be used more frequently to identify definite cardiac problems which will lead to more appropriate management.

Suspected PMI did not occur by chance. Effective preoperative evaluation and prediction of patient at risk were the keys of success to minimize perioperative cardiac adverse events and improve the outcomes. After the first published guidelines for preoperative cardiovascular evaluation from the American College of Cardiology (ACC) and American Heart Association (AHA) [11] in 1996, the guidelines were tested for the ability of prediction[3] .They concluded that, by their retrospective study, the predictor score performed extremely well with cardiac outcomes and adverse events, but related more to medical condition than the surgical factor. The later introduction that type of operation weighted for evaluation process was too crude to be useful. The guidelines were subsequently reviewed and were published in 2002.

From this study both ASA classification [12] and cardiac risk stratification by ACC/AHA guidelines could be used as predictor of cardiac risk. The incidence of PMI that was suddenly change from 3.42:10,000 in ASA class 2 to 10.02:10,000 in ASA class 3 corresponded to high frequency of suspected PMI in patient with intermediate and high cardiac risk (Table 1 and 2). Our results corresponded to studies of Lee TH, et al [13] and Gilbert K, et al [14] that power of predictability of adverse cardiac complications by ASA was nearly equivalent to modified cardiac risk index [2,11], Goldman index [15], modified Detsky index[16] and Canadian cardiovascular society index[13]. The predictability power was range from 0.66 to 0.71.

Our study confirmed the association between suspected PMI cases with some underlying diseases which included hypertension, ischemic heart disease and diabetes mellitus. Because of small number of suspected PMI cases in this study, we could not comfirm other valuable predicting risks such as age more than 70 year, uncompensated cardiac performance or renal failure [17] .

Most of suspected PMI in this study occurred during operations (Table2) which were diagnosed primary by EKG change and hypotension. This reflected the imbalance between myocardial oxygen demand and supply. In patient at risk, prolonged high sympathetic activity caused myocardial ischemia, myocardial injury and myocardial infarction. Prolonged physiological imbalance was precipitating cause of myocardial adverse events and could be mandated or modified by anesthetic management. Appropriate anesthetic management which included good preparation, appropriate control of stress response and early management or treatment of ischemic signs were medical process that could resolve ischemic process and prevent myocardial permanent damage. This process needed competent personal to make decision in anesthetic management. In medical setting, common cause of acute myocardial infarction came from sudden coronary occlusion. From this study, only two cases that sudden cardiac arrest and death occurred in day 2 after operations and both of them were confirmed of sudden coronary occlusion from autopsy. Others had ischemic pattern with unstable hemodynamics.

Both high percentage of serious outcomes (24.4%) and consumed more medical interventions

(Table 3) confirmed to all previous studies [1-5,15] that PMI was highly impact on both surgical and anesthesia outcomes and increased cost of medical care.

Even the systematic analysis documented that human failure was major contributing factor of anesthesia related to PMI. We were not expected that only additional training and quality assurance were enough strategies for improvement. Systematic arrangement of anesthetic service team had to guarantee management allocation of appropriate personal for high risk patients or high risk operations. At least, patient with ASA more than 2 should be under responsible of anesthesiologist not nurse anesthetist.

In conclusion, incidence of PMI was 2.7:10,000 of all anesthetic services. ASA and cardiac risk index could be used to predict adverse cardiac events. Increase detection of PMI cases via analysis cause of unstable hemodynamic, careful EKG monitoring and serial cardiac enzyme study in borderline cases were needed for more reliable incidence of PMI. Good systematic prevention of PMI could reduce cost of medical care and improved anesthetic outcomes.

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ภาวะกล้ามเนื้อหัวใจตาย หรือขาดเลือด : การศึกษาอุบัติการณ์จากโครงการเฝ้าระวังภาวะแทรกซ้อนทางวิสัญญีในประเทศไทย (ผู้ป่วย 163,403 ราย)

อรลักษณ์ รอดอนันต์, ฐิติมา ชินะโชติ, เทวารักษ์ วีรวัฒน์กานนท์, รัศนี เจริญกุล, วรรณา สมบูรณ์วิบูลย์, นีรดา กอจิตตวนิจ

วัตถุประสงค์: *เพื่อวิเคราะห์อุบัติการณ์ ปัจจัยเสี่ยง อาการทางคลินิก ผลที่เกิดจาก PMI ความสัมพันธ์กับการให้ยาระงับความรู้สึก การดูแลรักษา ปัจจัยเหนี่ยวนำ และกลยุทธ์ในการแก้ไข*

วัสดุและวิธีการ: *ศึกษาผู้ป่วยที่เกิดภาวะ PMI ในจำนวนผู้ป่วยทั้งหมดที่ได้จากการรวบรวมข้อมูลของการเฝ้าระวังภาวะแทรกซ้อนที่รุนแรงทางวิสัญญี (TAIS) ในช่วงระหว่างวันที่ 1 กุมภาพันธ์ พ.ศ. 2546 ถึง 31 มกราคม พ.ศ. 2547 และใช้การวิเคราะห์ข้อมูล โดยสถิติเชิงพรรณนา*

ผลการศึกษา: *พบผู้ป่วย 45 ราย ที่ได้รับการบันทึกว่าเกิดภาวะสงสัย PMI จากข้อมูลที่รวบรวมได้จากโรงพยาบาลต่างๆ จำนวน 20 โรงพยาบาล พบเป็นอุบัติการณ์เท่ากับ 2.7:10,000 จากจำนวนทั้งหมด 163,403 ราย พบภาวะ PMI ในผู้ป่วยชายมากกว่า หรือพบในผู้ป่วยที่มีโรคความดันโลหิตสูง เบาหวาน หัวใจขาดเลือด อยู่ก่อน ASA มากกว่า 2 ได้รับการให้ยาระงับความรู้สึกแบบทั่วไป และในระหว่างผ่าตัดพบว่ามีอาการแสดงนำที่สำคัญ คือ การเปลี่ยนแปลงของคลื่นไฟฟ้าหัวใจ และความดันโลหิตต่ำ การเกิด PMI ส่งผลให้เกิดความรุนแรงถึงตาย (5 ราย) พิการ (สมองตาย 6 ราย) ค่าใช้จ่ายในการรักษาเพิ่มสูงขึ้น และต้องเปลี่ยนแนวทางการรักษา*

สรุป: *PMI มีผลกระทบอย่างรุนแรงต่อผลจากการให้ยาระงับความรู้สึก และการผ่าตัด การเพิ่มคุณภาพ ในการดูแลผู้ป่วยทางวิสัญญีที่มีความเสี่ยงสูง จะสะท้อนให้เห็นถึงคุณภาพการให้บริการโดยรวมทางวิสัญญี*