The Thai Anesthesia Incident Monitoring Study (Thai AIMS): An Analysis of Perioperative Myocardial Ischemia/Infarction

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Objective: *To analyze the clinical course, outcome, contributing factors and factors minimizing the incidents of perioperative myocardial ischemia or infarction (PMI) from Thai AIMS study.*
Material and Method: *The present study was a prospective multicenter study. Data was collected from 51 hospitals in Thailand during a six-month period. The participating anesthesia provider completed the standardized incident report form of the Thai AIMS as soon as they found the PMI incident. Each incident was reviewed by three peer reviewers for clinical courses, contributing factors, outcome and minimizing factors of PMI.*
Results: *From the Thai AIMS incident report, the authors found 25 suspected PMI cases which was 0.9% of the 2,669 incidents reported in the present study. Most of the PMI occurred in elective cases (84%) and orthopedic procedures (56%). The majority of PMI was reported from the patients undergoing general anesthesia (72%). Suspected PMI occurred mostly during operations (56%). New ST-T segment change was detected in 92% of these patients. The most common immediate outcome of PMI was major physiological change (88%). The most common management effect of PMI was unplanned ICU admission (64%); the others were prolonged ventilatory support (12%) and prolonged hospital stay (16%). Four patients (16%) died after the suspected PMI. Most of the events occurred spontaneously and were unpreventable (80%). Patient factors (100%), anesthesia factors (72%), surgical factors (32%) and system factors (8%) were all judged as a precipitating factor for PMI. Human factors were the most common contributing factors which included poor preoperative evaluation, inexperience and improper decision. The three most common factors minimizing the adverse incidents included prior experienced, high awareness and experienced assistance. The recommended corrective strategies were guideline practice, quality assurance activity, improvement of supervision and additional training.*
Conclusion: *Perioperative myocardial ischemia/infarction was infrequent but may be lethal. Patient factors were the most common precipitating cause. The morbidity and mortality could be reduced by high quality preoperative evaluation and preparation, early detection and appropriate treatment. Guideline practice, quality assurance activity, improvement of supervision and additional training were suggested corrective strategies.*

Keywords: *Anesthesia, Adverse events, Multicenter study, Myocardial ischemia, Myocardial infarction, Incident report*

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Perioperative myocardial ischemia and infarction is uncommon but can lead to serious morbidity and mortality. Since cardiovascular diseases become one of the major health problems in every country, the prevalence of known and unknown cardiovascular diseases in the patient undergoing non-cardiac surgery has been increasing. In ischemic heart disease patients, the incidence of perioperative myocardial infarction is 1-4% with a very high mortality rate[1-6]. Beside the high risk population, the high risk procedure such as vascular surgery has increased risk of perioperative myocardial ischemia and infarction. Many previous studies tried to identify the incidence and risk factors for the cardiac adverse events[7,8].

In Thailand, the first multi-centered, national study on anesthesia-related, adverse outcomes or THAI Study reported the incidence of perioperative myocardial ischemia/infarction (PMI) as 2.7:10,000 of all anesthetic services[9]. 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[10]. Concerning to improve patient safety during anesthesia including perioperative and immediate postoperative care, many predictors for cardiac adverse events, preoperative risk assessment and management were identified[4,11-13]. The incident monitoring in anesthesia is another useful tool for quality improvement and to maintain the safety standard of care[14]. Voluntary self report, instead of assigning blame, encourages anesthesia providers to learn and improve the standard of care by detail analysis to prevent and reduce the risk as well as reduce the harm to the patients[15].

The aim of the present study was to identify the possible perioperative myocardial ischemia/infarction (PMI) from the voluntary incidents reported to the Thai Anesthesia Incident Monitoring Study (Thai AIMS) and then to analyze the clinical course, outcome, contributing factors and factor minimizing these incidents.

Materials and Method

Thai AIMS is a prospective multi-centered study conducted by the Royal College of Anesthesiologists of Thailand during a period from January to June 2007. Fifty-one hospitals ranging from primary to tertiary hospitals voluntary participated in the study. After approval by each institutional ethical committee, anonymous reporting of the adverse events during anesthesia and until 24 hours after operation from these hospitals was registered in the data entry form. Thai AIMS's details of studied methodology and preliminary results were previously described[16,17].

Myocardial ischemia or infarction (PMI) was suspected when a new ST-segment change happened together with symptomatic chest pain, or significant arrhythmia, or hypotension which could not be explained by other causes, or elevation of cardiac enzymes, or nitroglycerine was started for cardiac effect, or strong objective such as echocardiogram or autopsy.

Twenty-five records of possible perioperative myocardial ischemia/infarction were extracted from 2,537 incident reports in 1,996 patients from January to June 2007 for detailed analysis. These records were reviewed independently by three reviewers for the clinical course, contributing factors, outcome and factors minimizing these events. All data were analyzed by descriptive statistics using SPSS version 12.

Results

The relevant data of twenty five patients with suspected perioperative myocardial ischemia/infarction (PMI) were reported during the six months study period. This adverse incident accounted for 0.9% of all incident reports or 1.2% of the patients with adverse incidents. Beside the case of a 15 year old trauma patient with massive blood loss with intraoperative tachycardia and ST segment depression, the mean $\pm$ SD of age is 69.4 $\pm$ 11.2 with the range of 50 to 86 years. The suspected PMI occurred almost equally in both sexes. Other demographic data are shown in Table 1.

Seventeen patients (68%) had ASA physical status 3 while eight patients (32%) had ASA physical status 2. Most of the patients had underlying hypertension (68%) or baseline ECG abnormality (60%). Regarding anesthetic techniques, PMI were reported in eighteen of the general anesthesia cases (72%), seven cases of spinal block (28%) and one case of a patient receiving lumbar epidural block (4%). One of the patients under spinal block required general anesthesia because the procedure time was longer than the spinal anesthesia effect.

All of the operations were non-cardiac surgery. Most of the cases were elective cases in official time (84%). Suspected PMI occurred in ten cases of arthroplasty (40%), four cases of spine surgery (16%), four cases of urological procedure (16%), three cases of vascular surgery (12%), three cases of general surgery (12%) and one of gynecological procedure (4%).

Suspected PMI occurred mostly during operations (56%). Five cases occurred within 2 hours after operation (20%) and six cases occurred after 2

Table 1. Demographic, surgical and anesthetic characteristics (n = 25)

	Number	%
Age (yr)		
Range	50-86	
Mean ± SD	69.4 ± 11.2	
Weight (kg)		
Range	38-87	
Mean ± SD	58.6 ± 12.8	
Height (cm)		
Range	145-175	
Mean ± SD	158.7 ± 7.6	
Gender		
Male : Female	13:12	
ASA		
Physical status 2	8	32
Physical status 3	17	68
Official time		
Yes	21	84
Anesthetic technique		
General anesthesia	18	72
Spinal block	7	28
Epidural block	1	4
Type of surgery		
Arthroplasty	10	40
Spine surgery	4	16
Urology	4	16
Vascular surgery	3	12
General surgery	3	12
Gynecology	1	4
Underlying disease		
Hypertension	17	68
Abnormal EKG	15	60
Diabetes	4	16
Anemia	4	16
Hypovolemia	4	16
Renal failure	3	12
Electrolyte abnormality	2	8
Operative time (min)		
Range	45-420	
Mean ± SD	159.3 ± 89.0	

Values shown in number and %, range and mean ± SD (except age which calculated after exclusion of a 15 year old case)

Table 2. Details of events of suspected myocardial ischemia/infarction (n = 25)

	Number	%
Event occurrence*		
Intraoperative	14	56
Within 2 hour after operation	5	20
Postoperative > 2 hour	6	24
Primary symptoms/sign*		
New ST-T change	23	92
Significant arrhythmia	5	20
Chest pain	8	32
Dyspnea	2	8
Found dead at ward	1	4
Confirmed diagnosis of myocardial infarction*		
Yes	10	40
Positive cardiac enzyme	6	24
Echocardiogram	3	12
Autopsy	1	4
Precipitating risk*		
Patient factor	25	100
Anesthesia factor	18	72
Surgery factor	8	32
System factor	2	8
Preventability		
No	20	80
Yes	5	20

Value shown as number (%)
* Not mutually exclusive

Table 3. Outcomes and management effect (n = 25)

	Number	%
Immediate outcome		
Minor physiological change	3	12
Major physiological change	22	88
Final outcome		
Complete recovery	21	84
Death	4	16
Management effect		
Unplanned ICU admission	16	64
Prolonged ventilatory support	3	12
Prolonged hospital stay	4	16

Value shown as number (%)

postoperative-hours (24%). The most common sign of PMI is new ST segment or T wave abnormality (92%). Five patients developed significant arrhythmia including atrial fibrillation, supraventricular tachycardia or ventricular tachycardia (20%) together with new ST-T abnormality or congestive heart failure. Primary symptoms included typical chest pain in five patients (20%), atypical chest pain in three patients (32%), dyspnea in two patients (8%). Some of the primary symptoms developed intraoperatively in patients who received regional anesthesia. Some of the suspected postoperative myocardial ischemia/infarction occurred

Table 4. Contributing factors, factors minimizing incident and suggested corrective strategies (n = 25)

	Number	%
Contributing factors*		
Human factors		
Poor preoperative evaluation	21	84
Inexperience	11	44
Improper decision	9	36
Lack of knowledge	2	8
Haste	2	8
Communication failure	1	4
Emergency situation	5	20
Inadequate preparation	4	16
Lack of monitor/equipment	2	8
Monitor/equipment malfunction	2	8
No ICU for postoperative care	2	8
Factors minimizing incidents*		
Prior experience	24	96
High awareness	19	76
Experienced assistant	7	28
Consultations	6	24
Diagnostic monitor	4	16
Good communication	3	12
Improve training system	2	8
Comply to guidelines	2	8
Corrective strategies*		
Guideline practice	22	88
Quality assurance activity	17	68
Improved supervision	11	44
Additional training	10	40
More manpower	1	4
Improved communication	1	4

Value shown as number (%)
* Not mutually exclusive

without any presenting symptoms. Four patients died after the suspected PMI (16%), all of the mortality happened to the patients who developed symptoms postoperatively.

Case 1: A 72-year old man with hypertension, diabetes mellitus and chronic stable angina undergoing anterior corpectomy with cervical plate fixation at C4-6 level. The intraoperative period was uneventful. He developed chest pain, congestive heart failure together with atrial fibrillation and new left bundle branch block at 24 hours postoperatively. Echocardiogram confirmed LAD stenosis by hypokinesia with 10% ejection fraction. Shortly after that, he developed ventricular fibrillation, cardiac arrest and death.

Case 2: An 83-year old female with hypertension and first degree AV block scheduled for hip hemiarthroplasty under general anesthesia. At 24 hours postoperative, the patient developed hypotension together with new Q and inverted T wave. The patient was then transferred to the cardiac intensive care unit (CCU) with the diagnosis of myocardial infarction and cardiogenic shock. She developed cardiac arrest and died in the CCU.

Case 3: A 74-year old female with Parkinsonism, anemia with preoperative ECG showing anterolateral wall myocardial infarction with sinus tachycardia was scheduled for open hip reduction under general anesthesia. Two month earlier, she had bipolar hemiarthroplasty of this hip under general anesthesia without any complication. Her preinduction blood pressure was 91/40 mmHg and heart rate was 90/min. She had about 45-minutes period of hypotension (systolic blood pressure around 80 mmHg) without any ECG change after induction with very low intraoperative urine output. She was found dead in the ward the following morning.

Case 4: An 86-year old male with carcinoma of the bladder, renal failure and bilateral hydronephrosis scheduled for percutaneous nephrostomy under local anesthesia. He had inverted T wave in his preoperative ECG. The anesthesiologist was asked by the surgeon to provide general anesthesia in this case due to patient developing delirium on that day. Even though he had stable intraoperative hemodynamic with the unchanged inverted T wave, acidosis and hypocalcemia was detected from arterial blood gas and was treated. Within 2 hours postoperatively, he developed hypotension together with new inverted T wave in 12-lead ECG and elevated cardiac enzymes. This patient died in the 24 hour postoperative period.

Patient factors (100%), anesthesia factors (72%), surgical factors (32%) and system factor (8%) were all judged as a precipitating factor for PMI. Most of the events occurred spontaneously and were unpreventable (80%). Only five of these events could be prevented (20%). Among these five cases, two events were caused by human error: skill-based (8%) and one event was caused by human error: knowledge-based (4%)

The most common immediate outcome of PMI was major physiological changes (88%) including cardiovascular and respiratory system. Four cases (16%) were dead as a final outcome, while 21 cases were complete recovery (84%). The most common management effect of PMI was unplanned ICU admission (64%), the others were prolonged ventilatory support (12%) and prolonged hospital stay (16%).

Human factors were the most common contributing factors which included poor preoperative evaluation (84%), inexperience (44%), improper decision (36%), lack of knowledge (8%), haste (8%) and communication failure (4%). Emergency situation and inadequate preparation were analyzed as 20% and 16% of the contributing factors, respectively.

The three most common factors minimizing the adverse incidents included prior experience (96%), high awareness (76%) and experienced assistant (28%). While guideline practice, quality assurance activity such as morbidity and mortality conferences, improved supervision and additional training were suggested as the corrective strategies in 88%, 68%, 44% and 40%; respectively.

Discussion

Perioperative myocardial ischemia/infarction in patients undergoing non-cardiac surgery was not uncommon. In this study, this complication accounted for 1.2% of the anonymously and voluntarily reported cases of various adverse outcomes during the eight months period. The incidence of PMI in Thailand was 2.8:10,000 (0.0028%) for non cardiac surgery[10]. Even though the incidence went up to 11-12:10,000 (0.011%-0.012%) in ASA physical status 3-4, it was much lower than previous studies[1,3]. This number from the THAI Study was calculated after ruling out some cases who presented with pulmonary edema or significant arrhythmia. Moreover, the incidence of ischemic heart disease, a well-known risk for developing perioperative adverse events, was higher in the Western country[18].

The mortality rate after developing PMI in the present study was 16%, which was comparable with the study by Badner et al[5]. Mangano et al and Davenport et al reported the higher than 40% mortality rate after perioperative myocardial infarction. The authors calculated the mortality rate base on both perioperative myocardial ischemia and infarction, so the mortality rate was lower than calculated base on the myocardial infarction. Many predicting factors associated with perioperative cardiac complications including advanced age[7,8]. All of the mortality in the present study occurred in the patients with old age (> 70 year old), who developed myocardial infarction.

Zakowski et al reported ST segment depression in 26% of healthy women undergoing cesarean section, none of them suffered from myocardial infarction[19]. In the present study, the authors found ST segment changing in a teenage trauma patient. After blood transfusion and volume replacement, his intraoperative and hospital course was uneventful. This was most likely an ischemia which occurred from imbalance between myocardium demand and supply. The importance of intraoperative ECG finding depended on the possibility of the patient developing myocardial disease. The aggressiveness of management increased with the high risk patients and extended ST segment depression (> 2 hours)[3].

Hypertension was the most common underlying disease in the patients who developed PMI in the present study, followed by the baseline ECG abnormality. This finding was comparable to the study by Saki et al, who demonstrated hypertension as a factor for intraoperative cardiac complication, severity of coronary lesion and cardiac dysfunction as a factor for postoperative cardiac complications[20]. There was no difference in the adverse events among various anesthesia techniques.

None of the ASA physical status 4 or 5 patients was reported as a perioperative myocardial ischemia or infarction in the present study. Even with several workshops to instruct participants, it was the judgment of the anesthesia provider at the site of adverse events to categorize the outcome. Major adverse outcome in a very sick patient may be categorized as cardiac arrest or death without being categorized as PMI.

Emergency surgery was a risk factor for perioperative adverse outcomes[8]. However, more than half of the PMI in the present study happened with elective cases. Since the authors depended on the self report form for data collection, it was probably easier for the anesthesia provider to be encouraged to fill the form in the elective case rather than in the emergency case.

Orthopedic surgery, included arthroplasty and spine surgery, was the highest risk procedure in the present study since more than half of the PMI cases occurred in this group. Even though orthopedic surgery was an intermediate risk procedure while vascular surgery was a high risk procedure, according to the AHA guideline. Most of the orthopedic patients were extremely old with limited activity. Inadequate preoperative cardiac assessment combined with limited intensive care unit for postoperative monitoring compared to full investigation and ICU support in vascular surgery patients precipitated adverse cardiac outcome in the orthopedic group.

PMI occurred more frequently in the intraoperative period than in the postoperative period. However, most of the intraoperative PMI were an

ischemic episode which sometimes resolved without additional investigation or management. Myocardial infarction developed during the postoperative period more often than the intraoperative period. A previous study by Mangono et al confirmed that postoperative ischemic episodes were the most severe with a high mortality rate[21].

Sometimes ST segment depression occurred together with tachycardia. Faster heart rate increased myocardial demand and decreased myocardial supply, so tachycardia was one of the risk factors associated with postoperative ischemia[21]. Some of the PMI occurred as a silent episode[21]. In the present study, some of the conscious patients developed ST segment change without symptoms while some patients developed dyspnea or atypical chest pain. Many factors included analgesia after surgery, residual effects from anesthesia or other painful stimuli influenced these findings[2]. Since the sensitivity of single lead ECG monitoring to detect PMI was low, combined ECG monitoring of leads II and V5 or leads II, V4 and V5 increased the chance of abnormal ECG detection[22].

The main involving factor contributed to PMI in the present study was patient related (100%). This finding emphasized the importance of the patient predicting factor[4,12,13]. Anesthesia related factor, such as ST segment changed from stress, intubation or surgical incision was the second most important contributing factor. Even though most of these adverse events were unpreventable, the present study finding suggested the use of anesthesia management as a tool to improve the condition of the patients, especially for volume replacement and analgesia. Surgical factor and system factor responded for 32% and 8% respectively.

Unplanned ICU admission was the most common management effect of patients with PMI. This finding supported poor preoperative evaluation (84%) as the most magnificent contribution factor. Human error was the leading cause of all adverse events in the present study which was comparable to the Australian Incident Monitoring Study (AIMS)[23]. Poor preoperative evaluation (84%), improper decision (36%) and inexperience (44%), were the three main causes of the human error respectively. Emergency situation (20%) and inadequate preparation (16%) were analyzed as the contributing factors, especially for the mortality of the patient undergoing local anesthesia converted to general anesthesia without adequate evaluation and preparation. For the system factor, unavailability of the ICU for postoperative patient was demonstrated. Postoperative monitoring was very important since the mortality is highest in the postoperative myocardial ischemia/infarction patient.

In the present study, the common factors for minimizing incidents were prior experience, high awareness, experienced assistant and consultation. These factors made guideline practice, quality assurance activity, additional training and improved supervision were the most frequent recommendation for prevention of PMI.

In conclusion, perioperative myocardial ischemia/infarction was infrequent but associated with mortality. Patient factor were the most common precipitating factors. Even though most events occurred spontaneously, human factors were the most common contributing factors. The morbidity and mortality could be reduced by high quality preoperative evaluation and preparation, early detection and appropriate treatment. Corrective strategies including guideline practice, quality assurance activities, additional training and improved supervision were recommended to reduce this incident.

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การวิเคราะห์การเกิดกล้ามเนื้อหัวใจตายหรือขาดเลือดในระหว่างการให้ยาระงับความรู้สึกในประเทศไทย

พรสวรรค์ งามประเสริฐวงศ์, อินทิพร โฆษิตานุฤทธิ์, ปรีชายุทธ โยคะนิตย์, ฤทัย วรรธนวินิจ, สุนิดา อติชาติ, วรวุธ ลาภพิเศษพันธุ์

วัตถุประสงค์: *เพื่อวิเคราะห์ อาการ อาการแสดง ความสัมพันธ์กับการให้ยาระงับความรู้สึก การดูแลรักษา ปัจจัยเสี่ยง และการป้องกันเชิงระบบของปัญหาการเกิดกล้ามเนื้อหัวใจตายหรือขาดเลือดในระหว่างการให้ยาระงับความรู้สึก*

วัสดุและวิธีการ: *เป็นการศึกษาแบบพรรณนา โดยการเก็บข้อมูลแบบไปข้างหน้าในโรงพยาบาล 51 แห่งที่เข้าร่วมการศึกษาแบบสหสถาบันของการเกิดภาวะแทรกซ้อนทางวิสัญญีในประเทศไทยโดยการรายงานอุบัติการณ์ (Thai AIMS) อุบัติการณ์ของการเกิดกล้ามเนื้อหัวใจตายหรือขาดเลือดในระหว่างการระงับความรู้สึกจนถึง 24 ชั่วโมงหลังผ่าตัดจะถูกบันทึกในแบบฟอร์มมาตรฐาน แล้วนำมาวิเคราะห์*

ผลการศึกษา: *พบอุบัติการณ์ของการเกิดกล้ามเนื้อหัวใจตายหรือขาดเลือดในผู้ป่วย 25 รายคิดเป็นร้อยละ 0.9 ของอุบัติการณ์เกิดภาวะแทรกซ้อนที่ได้รับรายงานทั้งหมด โดยพบในผู้ป่วยที่ได้รับการนัดหมายให้มาผ่าตัด ร้อยละ 84 มากกว่าผู้ป่วยที่ได้รับการผ่าตัดแบบฉุกเฉิน และพบในผู้ป่วยที่ได้รับการผ่าตัดกระดูกและข้อมากกว่าการผ่าตัดชนิดอื่น ร้อยละ 56 ส่วนใหญ่เกิดในผู้ป่วยที่ได้รับการระงับความรู้สึก โดยการดมยาสลบ ร้อยละ 72 และเกิดในระหว่างการผ่าตัดร้อยละ 56 ภาวะแทรกซ้อนนี้ทำให้เกิดผลตามมาที่พบบ่อยที่สุดคือ การเข้ารับการรักษาต่อในหอผู้ป่วยหนักโดยไม่ได้วางแผนไว้ ร้อยละ 64 ผู้ป่วยต้องได้รับการช่วยหายใจต่อนานขึ้น ร้อยละ 12 และอยู่ในโรงพยาบาลนานขึ้น ร้อยละ 16 มีผู้ป่วยเสียชีวิตหลังเกิดภาวะแทรกซ้อนนี้จำนวน 4 ราย คิดเป็นร้อยละ 16 อุบัติการณ์ส่วนใหญ่เกิดขึ้นเองและไม่สามารถป้องกันได้ร้อยละ 80 สาเหตุเหนี่ยวนำให้เกิดภาวะแทรกซ้อนนี้เป็นปัจจัยจากผู้ป่วยเองร้อยละ 100 และเป็นปัจจัยทางวิสัญญีร้อยละ 72 บุคลากรที่ให้การดูแลผู้ป่วยเป็นปัจจัยเสริม อันได้แก่การประเมินผู้ป่วยก่อนผ่าตัดไม่ดีพอ ขาดประสบการณ์ หรือ ตัดสินใจไม่เหมาะสม ปัจจัยสำคัญที่จะช่วยลดอุบัติการณ์เกิดภาวะแทรกซ้อนนี้ ได้แก่ การมีประสบการณ์ การเพิ่มความระมัดระวัง ในการดูแลผู้ป่วย และการมีผู้ช่วยที่มีประสบการณ์*

สรุป: *การเกิดกล้ามเนื้อหัวใจตายหรือขาดเลือดในระหว่างการให้ยาระงับความรู้สึก แม้จะพบไม่บ่อยนัก แต่อาจนำไปสู่การเสียชีวิต ตัวผู้ป่วยเองเป็นปัจจัยนำที่สำคัญที่สุดที่ทำให้เกิดภาวะแทรกซ้อน ภาวะไม่พึงประสงค์นี้ สามารถทำให้ลดลงด้วยการประเมินและเตรียมผู้ป่วยก่อนผ่าตัดอย่างมีประสิทธิภาพ ร่วมกับการตรวจพบแต่เนิ่น ๆ พร้อมทั้งให้การรักษาอย่างเหมาะสม กลยุทธ์ที่แนะนำสำหรับอุบัติการณ์นี้ได้แก่ การปฏิบัติตามแนวทางเวชปฏิบัติ กิจกรรมพัฒนาคุณภาพการปรับปรุงระบบให้คำปรึกษา และการฝึกอบรมเพิ่มเติม*