The Thai Anesthesia Incident Monitoring Study (Thai AIMS) of Desaturation: An Analysis of 1,996 Incident Reports

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Background and Rationale: *The present study is a part of the Multicentered Study of Model of Anesthesia related Adverse Events in Thailand by Incident Report (The Thai Anesthesia Incident Monitoring Study or Thai AIMS). The objective of the present study was to determine the frequency distribution, outcomes, contributory factors, and factors minimizing incident.*
Material and Method: *The present study is a prospective descriptive research design. The authors extracted relevant data from the incident reports on oxygen desaturation from the Thai AIMS database and analyzed during the study period between January and June 2007.*
Results: *From the relevant 445 incidents, most of the incidents (89%) occurred in patients receiving general anesthesia. The incidence in patients receiving regional anesthesia was 4.0%. The events mostly occurred in patients aged between 16-65 years (52.8%). Most of the events (76%) took place in the operating theater during the induction period (30.1%). More than 81% of the patients experienced severe oxygen desaturation (SpO_2 < 85%). There were 55 patients (12.4%) who had unplanned ICU admission and 2 patients (0.4%) who had unplanned hospital admission. Factors that may relate to the incident involve combined factors (50.8%). Anesthetic factors were found to involve 38.4% of incidents. The common contributing factors that might lead to the incidents were inexperienced (57.5%), inappropriate decision (56.2%), and haste (23.8%). For factors minimizing incident, the important factors were vigilance (86.3%), experienced in that tropic (71.2%), and experienced assistance (54.8%). Quality assurance activity was the most common suggestive corrective strategy (79.1%). The others were improvement of supervision (47.2%) and guideline practice (46.5%).*
Conclusion: *To lower the incidence of oxygen desaturation, the anesthesia personnel has to improve the anesthesia services by quality assurance activity, improvement of supervision, clinical practice guidelines, and additional training.*

Keywords: *Oxygen desaturation, Hypoxemia, Pulse oximeter, Incident, Complications*

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Tissue oxygenation is one of the most important factors that concern anesthesiologists during the perioperative period. Tissue hypoxia especially in brain, heart, and kidney will cause adverse outcomes to the patient either minor or major like brain death or even death. Though using pulse oximetry during perioperative period has not yet been proved to improve the outcome of anesthesia, however it can help early detection of perioperative hypoxemia[1]. As a result, serious crisis may be prevented. The use of pulse

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oximetry can indirectly reflect tissue hypoxia. Since the introduction of pulse oximetry, its use has gained popularity. The reasons are that it is easy to use, be able to use continuously, and painless with few side effects. At the present time, pulse oximetry is recommended by many Collages of Anesthesiologists to be a standard monitoring during the perioperative period[2-4].

Concerning the patient's right to safety is growing around the world. Many patient-safety programs are ongoing in the hospitals worldwide. Anesthesiologists are claimed to be one of the most successful physicians in increasing patient safety during the last 20 years[5] by decreasing the risk of death from anesthesia from 1:5,000 to 1:250,000[6]. Anesthetic deaths have decreased since the progress of good anesthetic care given by anesthesiologists, guidelines, together with advanced anesthetic and monitoring equipments. It has been well accepted that incident reports is another mean to improve the quality of services in heath care[7-11].

The primary aim of the present study was to determine the frequency distribution, outcomes, contributory factors, and factor minimizing incidents of oxygen desaturation in a large scale in Thailand.

Material and Method

From January 2007 to June 2007, the Royal College of Anesthesiologists of Thailand conducted a prospective multi-centered study of incident reports from 51 hospitals ranging from primary to tertiary hospitals across Thailand. The present study was approved by each institutional ethical committee. The methodology of the present study has already been described[12]. The definition for desaturation in the present study was defined as oxygen saturation (SpO_2) < 90% for more than 3 minutes or < 85%.

In the present study, the authors included all the incidents that reported desaturation in form 1. The authors excluded patients with desaturation who underwent cardiac or thoracic surgery.

Data management was managed using SPSS for Window, version 12. Data was presented in number and percentage.

Results

During the six-month period, 1,996 incidents were reported which consisted of 491 records on desaturation. Excluding the patients who underwent cardiac and thoracic surgery, 473 incidents were remained. After reviewing all the remaining incidents, 26 reports were excluded from the present study because of the wrong criteria or inadequate data. The pulse oximeter was misleading in two cases, which were also excluded. In both cases, SpO_2 reading was 81%. The first case, arterial oxygen tension from arterial blood gas was 105 mmHg. The cause of the false reading was from vasoconstriction following the intravenous infusion of norepinephrine. The false reading of the other case was from shivering. After treating the patient with intravenous tramadol and the symptom was resolved, SpO_2 changed to 99%. The remaining 445 reports were enrolled in the present study.

There were 231 male patients and 212 female patients (Table 1). Most of the patients (69.7%) were in ASA physical status 1 and 2. Desaturation occurred more often in children under 5 years old (55%) than the other age groups when compared with all the ohter incidents reported in each age group (Fig. 1). According to the types of surgery, general surgery is the most common type (35.1%) that was related to desaturation. Desaturation occurred in 278 elective and 167 emergency cases respectively. Most of the desaturation incidents (362 cases; 81.3%) were severe (SpO_2 < 85%).

Three hundred and thirty eight, 85, and 23 events occurred during anesthesia, in the postanesthesia care unit (PACU), and at ward/intensive care unit (ICU) respectively. Most of the events occurred in the operating theater (75.3%). Two cases of desaturation occurred in 2 occasions. One patient had desaturation at the PACU and the ward. In the other one, the events occurred both during transfer and at the ICU. Over half (57.5%) of the incidents occurred during induction and maintenance (Table 2). The incidences in the PACU and emergence were 19.1% and 16.4% respectively. In the general anesthesia group with a total of 1,644 patients, desaturation occurred in 416 patients (25.3%). Only 18 patients (11.3%) out of 159 patients receiving major regional anesthesia experienced desaturation. For the patients who had general anesthesia, 273 patients had endotracheal intubations, 15 patients had nasotracheal intubation, 20 patients had LMA, 12 patients had tracheostomy, and 24 cases had under mask.

Fifty-five patients (12.1%) needed unplanned ICU admission and two patients (0.4%) needed unplanned hospital admission (Table 3). Twenty-nine patients died, which were mostly due to patients' illness. One patient died from uncontrolled bleeding in the trachea after biopsy of a mass. One patient died in the ICU after accidental extubation of the tracheostomy tube. The other patient died in the ward from inappropriate setting of the ventilator with subsequent subcutaneous emphysema. One case experienced cardiac

Table 1. Characteristic of the patients and types of surgery

Variables	n	%
Sex: Male patient	231	51.9
Female patients	212	47.6
Sex not defined	2	0.4
Age (year): Age < 5	104	23.4
Age 5-15	47	10.6
Age 16-65	235	52.8
Age > 65	59	13.3
ASA: ASA 1	134	30.1
ASA 2	176	39.6
ASA 3	90	20.2
ASA 4	33	7.4
ASA 5	10	2.2
ASA not defined	2	0.4
Elective surgery	278	62.5
Emergency surgery	167	37.5
General surgery	156	35.1
Orthopedic surgery	73	16.4
Otorhinolaryngological surgery	36	8.1
Plastic surgery	34	7.6
Gynecological surgery	32	7.2
Obstetrical surgery	23	5.2
Endoscopic procedure	22	4.9
Urological surgery	18	4.0
Neurosurgery	16	3.2
Others	11	2.5
Ophalmic surgery	8	1.8
Dental surgery	5	1.1
Diagnostic	5	1.1
Major vascular surgery	2	0.4
Radiotherapy	1	0.2
General anesthesia	396	89.0
General anesthesia (TIVA)	20	45.0
Monitor anesthesia care	8	1.8
Spinal anesthesia	17	3.8
Epidural anesthesia	1	0.2
Brachial block	1	0.2
Local tropical	2	0.4
SpO_2 < 90% for 3 minutes	83	18.7
SpO_2 < 85%	362	81.3

Table 2. Place and period of anesthesia where oxygen desaturation happened

	n	%
Place		
Operating theater	335	75.3
Post-anesthesia care unit	83	18.7
Ward	16	3.5
ICU	5	1.1
Transfer period	3	0.7
Induction room	2	0.4
Imaging suite	2	0.4
Others	1	0.2
Period		
Preinduction	9	2.0
Induction	134	30.1
Maintenance	122	27.4
Emergence	73	16.4
PACU	85	19.1
Post-recovery (24 hours)	23	5.2

PACU postanesthesia care unit

Table 3. Outcomes after the events of oxygen desaturation

	n	%
Immediate outcome (< 24 hours)		
Major physiological change		
Reintubation	17	3.8
Myocardial ischemia/infarction	3	0.7
Cardiac arrest	29	6.5
Death	29	6.5
Cancelled operation	9	2.0
Unplanned ICU admission	55	12.1
Unplanned hospital admission	2	0.4
Long term outcome (> 24 hours)		
Prolonged ventilatory support	2	0.4
Brain death	1	0.2
Death	1	0.2

arrest in the recovery room and died afterward. The causes might be from morbid obesity and hypoxia. Another patient died from delayed respiratory depression after spinal morphine.

From 445 incidents, 347 incidents were firstly detected by pulse oximeter before being clinically detected. The other 93 incidents were firstly detected by clinical signs. Reviewing all the incidents reported, pulse oximeter was ranked to be the first monitoring equipment to diagnosis the incidence in 394 (88.5%) patients.

The number of hospitals' beds joining the present study was between 20 and 2279 beds. Concerning the relationship between the number of hospital beds and the incidents, the authors found that desaturation happened more often (40%) in hospitals with fewer than 100 beds (Fig. 2) when compared with the other incidents that had no desaturation from each

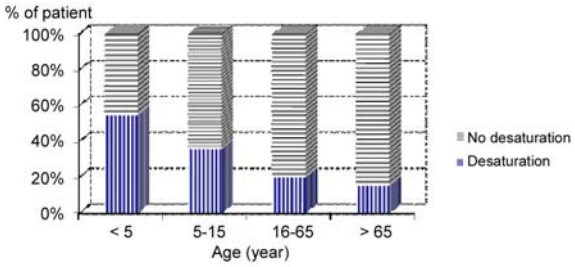

Fig. 1 Percentage of oxygen desaturation in each age group

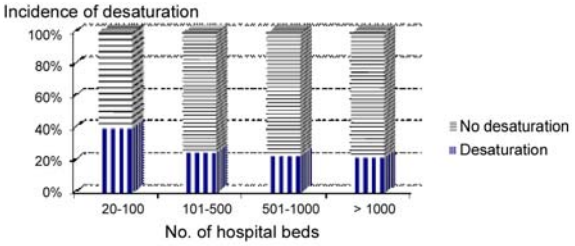

Fig 2. Percentage of incidents of oxygen desaturation in each hospital group

Table 4. Factors that may related to desaturation

Patient factors	
Anatomy difficult intubation	31
Underlying lung pathology; pneumonia, atelectasis, asthma, etc	30
Obesity	29
Secretion	25
Airway edema/injury/obstruction	18
Surgical factors	
Airway surgery	17
Massive blood loss	10
Anesthesia factors	
Laryngospasm	70
Delayed emergency from drug (55)/ muscle relaxant (13)	68
Inexperienced personnel in airway management	21
Hypoventilation from sedation	12
Airway obstruction from sedation	14
Accidental extubation	7
Airway obstruction from other causes; multiple attempt to intubation (3), toxic substance (1), retained gauze packing (1)	5
Improper size of endotracheal tube/ LMA	5
Air embolism from intravenous fluid bag	1

hospital group. While the incidences of desaturation in the hospitals with 101-500, 501-1000, and > 1000 beds were 25.5%, 23.2%, and 22.3% respectively.

One hundred and forty five incident reports were concluded to be preventable, which were 47 (32.4%), 80 (55.2%), and 18 (12.4%) in desaturation that occurred in the operating theater, PACU, and in the ward respectively. Two hundred and ninety nine incidents were caused by human error, which consisted of 203 (67.9%), 80 (26.7%), and 16 (5.4%) incidents that occurred in the operating theater, PACU, and in the ward respectively. One hundred and forty one, 131, and 234 incident reports were concluded to be rule-base, knowledge-base, and skill-base errors respectively.

Considering the factors that are related to desaturation, anesthesia-related factors alone were responsible for 171 incidents (38.4%), patient-related factors for 39 incidents (8.7%) and surgical-related factors for nine incidents (2.0%). However, another 226 incidents (50.8%) resulted from two or more of the above factors, a greater number than that resulting from any of the factors alone.

From the characteristics of the patients, the authors found that patients with difficult intubation by anatomy, retained secretion, obesity, airway edema/ injury/obstruction, and previous lung disease were prone to desaturation (Table 4). For surgical factors, desaturation commonly occurred in airway surgery as bronchoscope, palatoplasty, tonsillectomy, and tracheal reconstruction. The other common surgical factors were massive blood loss, which leads to hemodynamic instability. The common anesthetic factors that cause desaturation were laryngospasm and inappropriate extubation, which were mostly due to residual anesthetic drugs and some with muscle relaxant.

The authors found 15 episodes that were related to anesthetic machines or equipment malfunction and included circuit or chamber leakage, disconnection of common gas outlet, usage of wrong gas by error, laryngoscope without light, and oxygen transfer tank empty.

Concerning the contributing factors, inexperience and improper decision played a significant role in the occurrences of desaturation (Table 5). High awareness and experience in that situation might lessen the incidents (Table 6). Quality assurance activity, improved supervision, guideline practice, and additional training were the main suggested corrective strategies (Table 7).

Table 5. Contributory factors that may related to desaturation

Contributory factors	n	%
Inexperience	256	57.5
Improper decision	250	56.2
Poor evaluation	141	31.7
Haste (hurry)	106	23.8
Emergency	80	18.0
Long duration working	1	0.2
Inadequate staff	4	0.9
Communication failure	19	4.3
Lack of knowledge	54	12.1
Poor preoperative preparation	27	6.1
Poor equipment	13	2.9
Lack of monitor	12	2.7
Lack of equipment	3	0.7
Poor monitor	3	0.7
No recovery room	2	0.4
Others	23	5.2

Table 6. Suggested corrective strategy that may lower the incidents

Factors minimizing incident	n	%
High awareness	384	86.3
Experienced before	317	71.2
Experienced assistance	244	54.8
Consultations	24	5.4
Good communication	18	4.0
Following guidelines	18	4.0
Diagnostic monitor	16	3.6
Checking equipment (Calibration)	12	2.7
Improve training system	7	1.6
Preventive maintaining equipment	7	1.6
Adequate instrument	3	0.7
Adequate staff	2	0.4

Table 7. Suggested corrective strategy that may lower the incidents

Suggested corrective strategy	n	%
Quality assurance activity	352	79.1
Improved supervision	210	47.2
Guideline practice	207	46.5
Additional training	166	37.3
Improved communication	26	5.8
More equipment provided	24	5.4
Equipment maintenance	15	3.4
More manpower	9	2.0
Good referral system	2	0.4
Improving communication	2	0.4

Discussion

Desaturation was the most common adverse events from the authors' previous study. The incidences of desaturation in Thailand were between 0.37-0.00319%[13,14]. In the present study, 445 incidents reported on oxygen desaturation during perioperative period from 1996 incidents were found. This seems to be quite a higher number when compared with the other study. Szekely SM et al[15] reported 548 incidents of desaturation from their 4000 incident reports. This may be due to some of the anesthesia being performed by nurse anesthetists especially in small hospitals while all of the anesthesia in Australia was performed by anesthesiologists. Though the number of anesthesiologists here in Thailand has increased during the last decades, it still does not meet the requirement. This is a national problem and the Royal College of Anesthesiologists of Thailand is working in order to improve the anesthetic service throughout Thailand. Meanwhile, the authors attempt to improve the quality of care via other methods.

In the present study, the authors also found that the number of incidents on desaturation were higher in children than adults, which was compatible with the study of Bunchungmongkol N et al[16]. The younger the patients the higher the incidence of desaturation occurred. Pediatric patients might need skilled personnel to take care of them. Since Thailand does not have enough pediatric anesthesiologists like other countries, therefore, the services in the hospitals with a low volume of pediatric anesthesia might have problems.

Concerning the reports from the hospitals with 100 beds or less, the authors found more oxygen desaturation incidents than the other bigger hospitals when compared with the other incidents without oxygen desaturation. The total number of incidents reported on oxygen desaturation was 18. Any conclusion might not be made since these were only 45 incidents reported from this group of hospitals, which is just only 2.25% of all the incidents. So a larger number of incidents may be needed before any conclusion can be made in this topic. From the authors' methodology, most of the incidents reported from small hospitals should be minor because the facilities of these hospitals are limited. They cannot handle patients with severe diseases or giving major operation. If the authors want to compare the incidences among hospitals of any size, the authors might need to compare them with the incidence from all the anesthetic services in each hospital.

Most oxygen desaturation happened during induction (30.1%). This is the same as the authors' previous study[14] but it is different from the study of Szekely SM et al, which found the incidents most commonly during maintenance (52%)[15]. These were related to problems with airway management and intubation. Therefore, improving routine preoperative airway evaluation and high alert for difficult intubation will lower the incidence. Another problem is a routine check of anesthetic machines and circuits. The Royal Collegue of Anesthesiologists had developed a checklist for the anesthetic machines and equipment like the others[17].

It is known from many studies that some patients' characteristics made them prone to oxygen desaturation during the perioperative period such as pediatric patients, ASA physical status, obesity and underlying lung pathology, etc[18,19]. Therefore, much attention should be given during giving anesthesia care to these patients.

Oversedation is a major problem that caused oxygen desaturation at many stages during the perioperative period. It can cause airway obstruction, hypoventilation, or apnea during induction and maintenance. In addition, at the end of the operation when anesthesia personnel were in a hurry or had not well evaluated the patients before extubation, then the patients might suffer from airway obstruction or hypoventilation. Inexperienced in airway management, including not routinely preoperative airway evaluation, maintaining airway, and intubation skill would lead patients to oxygen desaturation. All these factors can be minimized by quality assurance activity, guideline practices and additional training. The other incidents were accidental extubation. This can be corrected by improvement of care and communication. Communication between colleagues is still a problem as there was also a patient with hypoventilation after spinal morphine, which also ended up with death.

Conclusion

Many factors are involved in the occurrence of oxygen desaturation during perioperative period. These include patient factors, surgical factors, anesthetic factors, and systemic factors. To improve the quality of anesthetic service, the morbidity and mortality rate have to be decreased. Therefore, the authors need to learn the mistakes and find the solutions to improved patient care. The suggested corrective strategies were quality assurance activity, improvement of supervision, clinical practice guidelines, and additional training.

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อุบัติการณ์การเกิดภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำจากการให้ยาระงับความรู้สึกในประเทศไทย

ศิริลักษณ์ สุขสมปอง, สุณิสา ฉัตรมงคลชาติ, ธนู หินทอง, ศิริลักษณ์ กล้าณรงค์, วราภรณ์ เชื้ออินทร์, ธนิต วีรังคบุตร

ที่มาและเหตุผล: *การศึกษานี้เป็นส่วนหนึ่งของการศึกษาแบบสหสถาบันของแบบจำลองการเกิดภาวะแทรกซ้อนทางวิสัญญีในประเทศไทยด้วยการรายงานอุบัติการณ์ (The Thai Anesthesia Incident Monitoring Study หรือ Thai AIMS) โดยการศึกษานี้เน้นเฉพาะรายงานที่เกี่ยวข้องกับภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำ วัตถุประสงค์ของการศึกษานี้ เพื่อหาอุบัติการณ์ ผลที่เกิด ปัจจัยนำ และปัจจัยลดอุบัติการณ์*

วิธีการศึกษา: *เป็นการศึกษาเชิงพรรณนาจากการวิเคราะห์ข้อมูลที่ได้จากการศึกษาแบบสหสถาบันของแบบจำลองการเกิดภาวะแทรกซ้อนทางวิสัญญีในประเทศไทยโดยการรายงานอุบัติการณ์ ระหว่างเดือนมกราคม ถึง เดือนมิถุนายน พ.ศ. 2550*

ผลการศึกษา: *จากการวิเคราะห์รายงานอุบัติการณ์ของผู้ป่วยที่เกิดภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำจำนวน 445 ราย พบว่าอุบัติการณ์นี้เกิดในผู้ป่วยที่ได้รับการให้ยาระงับความรู้สึกแบบทั้งตัว (ร้อยละ 89) บ่อยกว่าผู้ป่วยที่ได้รับการให้ยาระงับความรู้สึกแบบเฉพาะส่วน (ร้อยละ 4.0) และพบบ่อยในผู้ป่วยอายุระหว่าง 16-65 ปี (ร้อยละ 52.8) ทั้งนี้เหตุการณ์ส่วนใหญ่เกิดขึ้นในห้องผ่าตัด (ร้อยละ 76) และเกิดในขณะนำสลบ (ร้อยละ 30.1) ร้อยละ 81.3 ของผู้ป่วยจะมีภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำที่รุนแรงคือ SpO_2 น้อยกว่า 85% มีผู้ป่วยต้องเข้ารับการรักษาตัวในหออภิบาลผู้ป่วยหนักโดยไม่ได้วางแผนไว้ล่วงหน้า 55 ราย (ร้อยละ 12.4) และมีผู้ป่วยที่ต้องเข้ารับการรักษาตัวในโรงพยาบาลโดยไม่ได้วางแผนไว้ล่วงหน้า 2 ราย (ร้อยละ 0.4) ปัจจัยที่ทำให้เกิดอุบัติการณ์มักจะมีหลายปัจจัยร่วมกัน คิดเป็นร้อยละ 50.8 ขณะที่ปัจจัยทางวิสัญญีเป็นสาเหตุรองลงมาคือ ร้อยละ 38.4 โดยปัจจัยอื่นที่มีส่วนเกี่ยวข้องที่สำคัญได้แก่ การขาดประสบการณ์ (ร้อยละ 57.5) การตัดสินใจที่ไม่เหมาะสม (ร้อยละ 56.2) ความรีบร้อน (ร้อยละ 23.8) สำหรับปัจจัยที่จะสามารถช่วยลดอุบัติการณ์ได้แก่ การมีความระแวดระวังสูง (ร้อยละ 86.3) การเคยมีประสบการณ์ในเรื่องนั้น ๆ มาก่อน (ร้อยละ 71.2) และการมีผู้ช่วยที่มีประสบการณ์ (ร้อยละ 54.8) ส่วนวิธีการแก้ไขปัญหาได้แก่ การจัดประชุมเพื่อประเมินคุณภาพการบริการ (ร้อยละ 79.1) การพัฒนาการดูแลระบบการทำงาน (ร้อยละ 47.2) และการมีแนวทางการปฏิบัติงานในเรื่องต่าง ๆ (ร้อยละ 46.5)*

สรุป: *การลดอุบัติการณ์ภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำจากการให้ยาระงับความรู้สึกในประเทศไทยนั้นสามารถทำได้จากการปรับปรุงคุณภาพของการให้บริการทางวิสัญญีโดยกิจกรรมประกันคุณภาพ ปรับปรุงระบบการให้คำปรึกษา การสร้างแนวทางเวชปฏิบัติ และการฝึกอบรมเพิ่มเติม*