Perioperative Desaturation : Incidence, Causes, Management and Outcome

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Abstract

Objective : To determine the incidence, causes, management and outcome of desaturation occurring in the perioperative peroids (induction, maintence, emergence and recovery room) at Siriraj Hospital from June 2001-December 2001.

Method : Perioperative incident reports were collected and analyzed. Patients were catergorized as having desaturation if the SpO_2 was below 90 per cent for more than 3 minutes. The incidence, causes, management, and outcomes of these patients were examined in detail.

Results : 62 out of 16,716 cases (0.37%) experienced desaturation. Elective patients (0.41%) experienced desaturation more frequently than emergency patients (0.14%). The causes were airway obstruction, hypoventilation, endotracheal tube problems, aspiration, atelectasis, and pulmonary edema. These patients were treated with higher FiO_2, airway management, and ventilatory support which led to unplanned ICU admission. 4 patients developed cardiac arrest with successful resuscitation although 2 patients had cerebral infarction.

Conclusion : Perioperative desaturation is an important sign of respiratory complications that should be recognized and treated immediately to prevent mortality and serious morbidity.

Key word : Desaturation, Perioperative, Audit

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Although mortality and major morbidity related to anesthesia are uncommon, minor morbidity such as desaturation occurs frequently[1-6]. Most studies reported have different definitions for desaturation. Desaturation has been defined as SpO_2 less than 85-95 per cent[1-6] for any period of time or a decrease in oxygen saturation of more than 5 per cent below baseline for at least 10 seconds[7]. Very brief periods of desaturation happen frequently without major harm but a longer period of desaturation can lead to more serious complications such as perioperative myocardial ischemia[6] or unplanned ICU admission[3].

Perioperative desaturation related to respiratory events has been investigated, including causes, associated risk factors, and patient outcome[8-13]. In Thailand, we are unaware of any report related to the incidence of respiratory complications or desaturation, so we collected data concerning anesthesia related complications at Siriraj hospital as a part of our quality assurance plan.

METHOD

The study was conducted prospectively at Siriraj Hospital, a tertiary university hospital of 2,500 beds from June 2001- December 2001. We obtained data from all patients who underwent elective (14,010) and emergency (2,706) surgery. There were 7,589 cases who received tracheal intubation, while (9,127) received regional anesthesia or general anesthesia without tracheal intubation (GA with mask or laryngeal mask airway (LMA)) or total intravenous anesthesia (TIVA) or monitored anesthetic care (MAC).

Desaturation was defined as a SpO_2<90 per cent which lasted longer than 3 minutes. We chose 3 minutes because we wanted to isolate episodes of serious desaturation which could lead to major morbidity or mortality. Patients who were already desaturated as a result of cyanotic heart diseases were excluded.

The occurrence of desaturation was documented by anesthetic personnel in the operating room or by the nurses in the recovery room. The management of desaturation was at the discretion of the individual anesthesiologist. An oxygen face mask was routinely used during patient transfer and in the recovery room until the patient was ready to be discharged to the ward. Some patients went to ICU directly (planned and unplanned).

Every incident reports with "yes" for desaturation was examined in detail. The information came from anesthetic records, patient notes, and interviewing the anesthetic personnel who were in charge in order to determine the causes, management and outcomes. Statistical significance was determined using chi-square or Fisher's exact test ($p<0.05$).

RESULTS

There were 16,716 patients included in this study. 14,010 patients (83.8%) had elective operations, 2,706 (16.2%) patients had emergency operations. 62 patients (ages varied from less than one year to more than 60 years old) experienced an episode of desaturation. The incidents occurred in both sexes with all types of operations (Table 1).

58 out of 14,010 (0.41%) elective cases had severe desaturation but only 4 out of 2,706 (0.14%) emergency cases had the same problem (Fig. 1). Desaturation occurred more frequently with elective patients ($p<0.001$).

7,589 patients required tracheal intubation during the operation while 9,127 had regional anesthesia or general anesthesia without insertion of an

Table 1. Patients' characteristics and operations.

	Number of cases
Age	
<1 year	5
1-15	9
16-40	24
41-60	7
>60	17
Sex	
Male	28
Female	34
ASA	
1-2	41
3-5	21
Operation	
CVT	2
ENT	5
Eye	2
General	15
Head and neck	1
Neurosurgery	1
Obstetric and gynecology	10
Orthopedic	12
Pediatrics	4
Plastic	3
Scope/ERCP	2
Urology	5

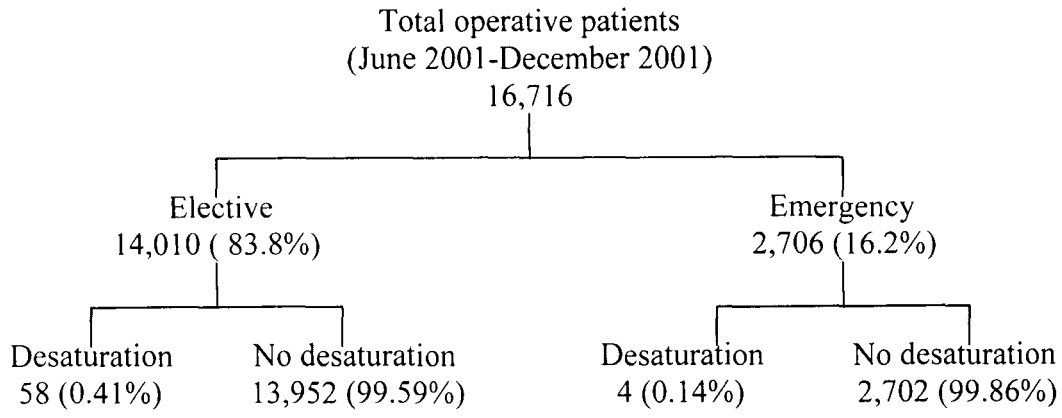

Fig. 1. The incidence of perioperative desaturation occuring with elective and emergency patients.

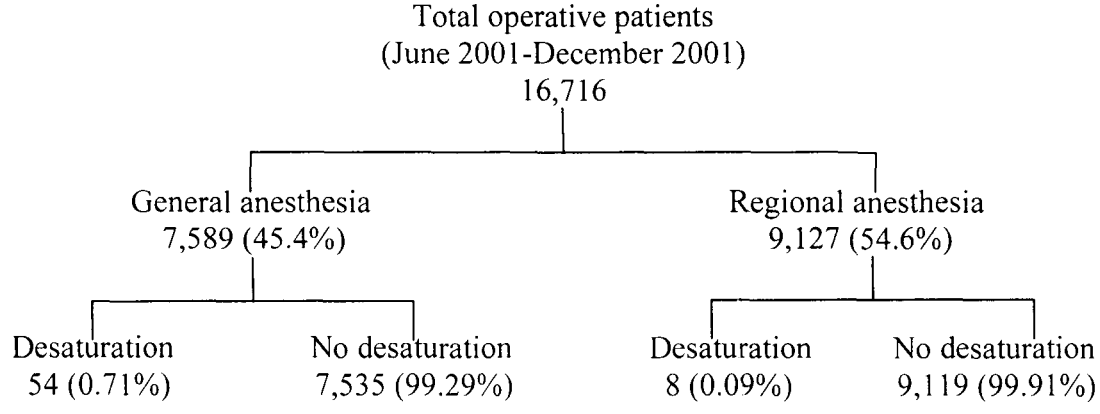

Fig. 2. The incidence of perioperative desaturation occuring in intubated and non-intubated patients.

endotracheal tube or monitored anesthetic care. 54 out of 7,589 (0.71%) intubated patients experienced desaturation although only 8 out of 9,127 (0.09%) non-intubated patients had desaturation (Fig. 2). Desaturation occurred more frequently with intubated patients ($p<0.001$).

The incidents happened during induction (14), during maintenance(19) during emergence(5), and in the recovery room(24). During the induction period, the causes of desaturation were airway obstruction (defined as stridor, laryngospasm, paradoxical breathing), aspiration (defined as a witnessed episode of content entering trachea, bronchospasm and desaturation) and late detection of esophageal intubation. The major morbidity outcomes were operation postponement and unplanned ICU admission (Table 2).

During maintenance, the causes were endotracheal tube (ETT) problems, hypoventilation (increase end-tidal CO_2 in ventilated patients or signs of inadequate ventilation), pneumonia/atelectasis (proven on chest X-ray). ETT problems were kinking, obstruction by secretions, leak, accidental extubation, and unintentional endobronchial intubation (Table 3). The major morbidity outcomes were unplanned ICU admission and cardiac arrest.

During emergence, only 5 patients had desaturation. 4 patients had severe upper airway obstruction after extubation. 1 out of 4 had obstructive pulmonary

Table 2. The causes of desaturation occuring during the induction period and major outcomes.

Induction (n=14)	No. of cases	Major morbidity outcome	No. of cases
Airway obstruction	4	Operation postponement	4
Aspiration	6	Unplanned ICU admission	2
Esophageal intubation	4		

Table 3. The causes of desaturation occurred during maintenance period and major outcomes.

Maintenance (n=19)	No. of cases	Major morbidity outcome	No. of cases
ETT problems-kink	1	Unplanned ICU admission	3
Secretion	3	Cardiac arrest, CPR, ICU admission	3
Leak	1		
Accidental extubation	2		
Endobronchial intubation	8		
Hypoventilation	2		
Pneumonia/atelectasis	2		

Table 4. The causes of desaturation occuring during the emergence period and major outcomes.

Emergence (n=5)	No. of cases	Major morbidity outcome	No. of cases
Upper airway obstruction	4	Reintubation and unplanned ICU admission	3
Hypoventilation	1		

Table 5. The causes of desaturation occuring in the recovery room and major outcomes.

Recovery room (n=24)	No. of cases	Major morbidity outcome	No. of cases
Upper airway obstruction		Reintubation and unplanned ICU admission	17
(airway edema or vocal cord paralysis)	7	Cardiac arrest, CPR, ICU admission	1
Hypoventilation (lung pathology)	3		
Upper airway obstruction and			
hypoventilation (inadequate awakening)	7		
Pneumonia/atelectasis	3		
Cardiogenic pulmonary edema	3		
Aspiration	1		

edema. 1 hypoventilated patient could not breath adequately (RR<8/min) despite a good airway (Table 4). The major morbidity outcomes were reintubation and unplanned ICU admission.

At the recovery room, 24 cases had desaturation. The causes were upper airway obstruction, hypoventilation, a combination of both upper airway obstruction and hypoventilation, pneumonia/atelectasis, cardiogenic pulmonary edema and aspiration (Table 5). The major morbidity outcomes were reintubation, unplanned ICU admission and cardiac arrest.

Every patient was managed with airway manipulation (manual manipulation or insertion of an oral/nasal airway) or assisted ventilation or opioid antagonism or relaxant antagonism or reintubation and mechanical ventilation or of combination of more than one method.

The total major outcomes were operation postponement(4), unplanned ICU admissions(5), reintubation and unplanned ICU admissions(20), and cardiac arrest(4). Although 4 patients who developed cardiac arrest had successful resuscitation, 2 patients had permanent cerebral damage. Twenty-four

patients who were admitted to the ICU, most could be extubated the next day or within the next few days. One patient needed a tracheostomy because of bilateral vocal cord paralysis.

DISCUSSION

The overall incidence in this study of desaturation was 0.37 per cent which was extremely low as a result of our criteria for desaturation (SpO_2<90%, lasts>3 min) or under reporting. It occurred in all age groups and all types of operations. Moller, et al reported an incidence of 53 per cent with mild hypoxemia (SpO_2<90%) and 20 per cent with severe hypoxemia (SpO_2<81%) respectively with a duration of 20-2,080 seconds. In our study, although the incidence was low, they had a major impact. Very surprisingly, it occurred more frequently with elective cases. This could be explained by several reasons. First, elective patients were considered to have "empty stomach" and could be extubated while in a deeper plane of anesthesia compared with emergency patients. Second, elective schedules were tight and the anesthesiologists had to extubate these patients eventhough the extubation criteria had not yet been reached. Third, trainees did more with elective cases under supervision than they would be allowed to do for emergency patients.

Not surprisingly this study also showed that intubated patients experienced desaturation more frequently than non-intubated patients. Most of the non-intubated patients had regional anesthesia. We know that regional anesthesia is accompanied by a significantly lower risk of hypoxemia. In these cases desaturation occurred as a result of intravenous sedation which led to airway obstruction and hypoxemia. Only one patient in this group had cardiogenic pulmonary edema when the block was wearing off. Although very few patients had GA with mask or LMA, there were 2 patients had severe laryngospasm and desaturation.

The desaturation could occur at different periods of anesthesia and also in the recovery room. During induction, desaturation was associated with airway management such as airway obstruction, aspiration, and late detection of esophageal intubation. In our hospital, we routinely preoxygenate every patient before induction. Although pulse oximetry is routinely used, end-tidal carbon dioxide (Et CO_2) is not because of lack of equipment. If we had Et CO_2 for every patient, the late detection of esophageal intubation might not have occurred.

Aspiration pneumonitis ocuurred in only 7 patients out of 16,716 patients and the incidence is extremely low. Soreide, et al[12] conducted an audit of perioperative aspiration pneumonitis in gynecological and obstetric patients and only 11 out of 25,330 patients had aspiration penumonitis. Our incidence is slightly higher than their incidence. The incidents occurred mostly at induction and were associated with difficult intubation. We also do not routinely use drugs for acid aspiration prophylaxis apart from 0.3 M NaCitrate which is given to pregnant women undergoing cesarean section under general anesthesia. Expected and unexpected difficult intubation (>2 attempts) occurred quite frequently which could lead to pulmonary aspiration. Should we use more prophylaxis drugs for expected difficult intubation? Will they decrease the desaturation incidence in the induction peroid? More studies are needed. In this study, there were 4 patients whose operations were postponed, but for the remaining (10 patients), the anesthesiologists decided to continue the operations. 2 out of these 10 patients went to ICU for ventilatory support and close observation.

In the maintenance period, ETT problems were the most common causes of the desaturation. Could ETT problems be detected by other means? Many of these patients had higher airway pressures, bronchospasm, diminished breath sounds and increasing Et CO_2. Mostly hypoxemia (desaturation) was the earliest sign of ETT problems. Again these problems led to unplanned ICU admission. Two patients had hypoventilation due to machine leakage and surgical airway tear. In this period, 3 patients developed cardiac arrest because of prolonged hypoxemia. Although the cardiac arrest was witnessed and resuscitaion was successful, two patients had permanent cerebral damage. The desaturation alerted us but frequently, it took time to find out and correct the cause.

During emergence, only 5 patients experienced episodes of desaturation which were caused by upper airway obstruction and hypoventilation. 3 patients needed immediate reintubation and ICU admission. The others improved after inserting oral/nasal airways and opioid antagonism or a second dose of relaxant antagonism. These incidents did not include patients who had planned ICU admission and went directly to ICU. Most of these patients had airway surgery, thoracotomy or major abodominal surgery. Xue, et al[2] found that the early postoperative hypoxemia occurred more with thoracotomy and major abdominal surgery compared with superficial

surgery. Rosenberg, et al[7] found that the hypoxemia also happened in the late postoperative period on the general surgical ward. The anesthesiologists expected these patients would be desaturated if they were extubated immediately at the end of operation so they did not extubate them.

In the recovery room, desaturation occurred more frequently compared with other periods for several reasons. First, the recovery nurses take care of more than one patient at a time. Second, during emergence we stimulated our patients by calling and suctioning so they looked fully awake but many of them fell asleep in the recovery room. Third, many patients had cold extremities which made pulse oximetry monitoring more difficult and inaccurate[14]. Fourth, the upper airway obstruction from airway edema or vocal cord paralysis could not be recognized until extubation[15]. Fifth, patients with lung pathology had worsening respiratory function as a result of anesthetic and surgical factors and were more likely to experience postoperative respiratory complications[2,9,10,13,15]. There were 3 patients with cardiogenic pulmonary edema caused by volume overload. Symptoms also occurred after extubation when the patients had to create negative pressure for spontaneous breathing. One patient developed cardiac arrest during reintubation. The resuscitation was successful and he had no permanent cerebral damage.

Can we prove the benefits of monitoring? Moller, et al[5,6,16] conducted a trial 20,802 patients scheduled for elective surgery randomly assigned to received monitoring with pulse oximetry or not. They found that using the pulse oximetry increased the detection of perioperative hypoxemia 20 times although there were no differences in the cardiovascular or neurological outcomes. Our study was not a randomized controlled trial because pulse oximetry is the standard monitoring used in our hospital. Even with pulse oximetry to help us detect hypoxemia early, many patients did have major morbidity. Pulse oximetry is undoubtedly a standard monitoring during anesthesia. Our incident report form has not yet been completed but this is the first step in anesthesia audit in Thailand. The first public demonstration of anesthesia occurred more than 150 years ago[17] and the quality of care improves all the time. Is it time for all the anesthesiologists in Thailand to provide the same standard of care? The incident report form can undoubtedly be used as a tool of quality assurance/ audit.

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ภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำระหว่างการผ่าตัด : อัตราการเกิด สาเหตุ การแก้ไขและผลที่เกิดขึ้น

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วัตถุประสงค์ : เพื่อทราบอัตราการเกิด สาเหตุ การแก้ไขและผลที่เกิดขึ้นในผู้ป่วยที่มีภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำระหว่างการผ่าตัด (ช่วงนำสลบ ระหว่างการผ่าตัด ระยะฟื้นจากยาและในห้องพักฟื้น) ในโรงพยาบาลศิริราช ระหว่างมิถุนายน 2544 ถึงธันวาคม 2544

วิธีการ : รายงานอุบัติการณ์ได้ถูกเก็บรวบรวมและนำมาวิเคราะห์ ผู้ป่วยที่ถูกนำมาศึกษาจะต้องมีภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำกว่าร้อยละ 90 นานกว่า 3 นาที ผู้ป่วยแต่ละรายถูกศึกษาในรายละเอียดเกี่ยวกับสาเหตุ การจัดการแก้ไขที่ผู้ป่วยได้รับและผลที่เกิดขึ้นกับผู้ป่วย

ผลการศึกษา : มีรายงานทั้งหมด 62 ครั้งจากผู้ป่วยทั้งหมด 16,716 คนคิดเป็นร้อยละ 0.37 ผู้ป่วยที่มารับการผ่าตัดไม่ฉุกเฉิน (ร้อยละ 0.41) เกิดภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำบ่อยกว่าผู้ป่วยที่มารับการผ่าตัดฉุกเฉิน (ร้อยละ 0.14) สาเหตุที่ทำให้เกิด ได้แก่ ทางหายใจถูกปิดกั้น หายใจน้อย มีปัญหาเกี่ยวกับท่อหายใจ การสูดสำลักสิ่งแปลกปลอมเข้าปอด ปอดบวมน้ำ ผู้ป่วยได้รับการรักษาด้วยการให้ออกซิเจนความเข้มข้นสูงขึ้น เปิดทางหายใจและช่วยหายใจ และผู้ป่วยบางรายได้รับการรักษาต่อที่หอผู้ป่วยหนัก มีผู้ป่วย 4 รายเกิดภาวะหัวใจหยุดเต้นและได้รับการฟื้นคืนชีพซึ่งผู้ป่วย 2 ใน 4 รายนี้เกิดภาวะสมองขาดเลือด แต่ไม่มีผู้ป่วยที่เสียชีวิต

สรุป : ภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำเป็นอาการแสดงที่สำคัญของความผิดปกติของระบบหายใจ ซึ่งควรได้รับการรักษาและแก้ไขสาเหตุอย่างทันท่วงที เพื่อป้องกันไม่ให้เกิดอันตรายแก่ผู้ป่วย

คำสำคัญ : ความอิ่มตัวของออกซิเจนในเลือด, ระยะผ่าตัด, การตรวจประเมิน

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