Original Article

Esophageal Intubation in the First 2,000 Incidents Reports of Perioperative and Anesthetic Adverse Events in Thailand [PAAd Thai] Study

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Background: Esophageal intubation [EI] is one of the most common events in perioperative airway management especially in anesthesia training situations.

Objective: To examine incidents and contributing factors including corrective strategies of EI in the Perioperative and Anesthetic Adverse Events in Thailand [PAAd Thai] Study, hosted by the Royal College of Anesthesiologists of Thailand.

Materials and Methods: A multi-center prospective observational study was conducted between January and December 2015. All EI incidents from the first 2,000 incident reports from 22 participating hospitals across Thailand were reported and analyzed using descriptive statistics.

Results: One hundred sixty-nine EI incidents (8.45%) were reported from the first 2,000 incident reports in the PAAd Thai database. The incidence of delayed detection of EI was rare (0.28:10,000). Practice with trainees is a common situation (55.6%), however, most cases were early detection by clinical examination and/or capnometer without physiologic sequelae. Pediatric patients, cesarean section, and difficult intubation may lead to oxygen desaturation, with few cases of oxygen desaturation and bradycardia.

Conclusion: While the EI incidence rates in Thailand remained constant, the incidence of delayed detection was dramatically reduced because of increased availability of end-tidal carbon dioxide monitoring. Vigilance, additional training, and more equipment availability are recommended.

Keywords: Esophageal intubation, Incident report, Outcome, Monitoring, Adverse events, Complication

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Esophageal intubation [EI] is a common situation in routine anesthesia practice especially for trainees. Fortunately, most cases are detected early by vigilant trainers and patients are not affected. On the other hand, delayed detection of EI is more catastrophic and may lead to lawsuits[1-3]. Sensitivity and specificity of various methods of detection of EI have been proposed. End-tidal carbon dioxide is the most reliable method for early detection. It also improves the reliability of clinical signs[4].

According to a THAI-study, a multicentered survey study of anesthesia incidents in Thailand in 2005, the registry revealed that the capnometer use rate was only 19% in daily practice[5]. Without end-tidal carbon dioxide, the detection of tracheal tube depends on observation of chest movement, listening of breath sounds at the stomach area, vapor of water condensation in the tracheal tube, and audible rattle around the tracheal tube during ventilation. All of these clinical signs require experienced individual healthcare personnel and reliability is often limited.

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The aims of this study were to determine the incidence of early and delayed detection of EI in the Perioperative and Anesthetic Adverse Events in Thailand [PAAd Thai] Study[6,7]. It is also to determine the benefits and availability of capnometer in anesthetic practice. Analyses of risks, contributing factors, factors minimizing incident, and suggested corrective strategies was also done.

Materials and Methods

The PAAd-Thai Study is a multi-center prospective observational study conducted at 22 hospitals across Thailand between January and December 2015. Data of all EI from the first 2,000 cases in each specific incident were sent for analysis[7]. The study protocol was approved by each institutional ethics committee before collection. All EI incident record forms were reviewed by three anesthesiologists for completion, identifying mechanisms, contributory factors, factors minimizing incident, and suggested corrective strategies. Any controversy was discussed to achieve a consensus[7]. Descriptive statistics were used to present the data by SPSS version 22.

Delayed detection of EI was defined as misplacement of tracheal tube that was detected late until clinical hypoxia or oxygen saturation of less than 85% developed. Patients less than 15 years old were assigned to the pediatric group. Patients who had at least one difficult intubation characteristic were considered as suspected difficult intubation. In addition, patients in the unexpected difficult intubation group were assigned from the details of events. Those with pulse oximeter showing less than 85% or 90% for three minutes were considered as oxygen desaturation[7].

Results

In the PAAd Thai database, there were 216,179 cases of general anesthesia. One hundred seventy-four cases of EI were collected. Five cases were excluded due to irrelevance according to the definition. Therefore, 169 cases of EI were enrolled. Ninety-four cases (55.6%) occurred in training situations and 75 cases (44.4%) in non-training practice. Incidents were reported from non-university hospitals with 112 (66.3%) and 57 (33.7%) from university hospitals as shown in Table 1. Age ranges were classified as pediatric and adult groups. The number of pediatric and adult cases were 21 (12.43%) and 148 (87.57%), respectively.

One hundred sixty-three cases (96.4%) were detected early by clinical sigus and confirmed later by capnometer. Delayed detection of EI was reported in only six cases (3.6%). The rate of end-tidal carbon dioxide monitoring during intubation period was 64.5%. However, clinical diagnosis of EI was achieved before capnometer in 90 cases (53.3%). On the other hand, 19 incidents (11.2%) were diagnosed with tracheal misplacement by monitoring only or monitoring before clinical diagnosis. End-tidal carbon dioxide monitoring was not used in 36 cases (21.3%).

One hundred forty-eight cases (87.6%) were considered as preventable and due to human error. Errors were classified as rule-based (5.3%), knowledge-based (46.7%), skill-based (37.9%), and combined (2.4%). However, 20 cases (12.43%) were considered spontaneous or unpreventable. Incident related factors considered by reviewers are demonstrated in Table 2.

According to system analysis, contributing factors, factors minimizing incident, and suggested corrective strategies are shown in Table 3.

Table 1. Demographic data and details of events and outcomes (n = 169)

Demographic data or Details of events	n (%)
Age group	
Pediatric (<15 years)	21 (12.4)
Adult (≥15 years)	148 (87.6)
Type of hospitals	
University	57 (33.7)
Non-university	112 (66.3)
Time to detection of EI	
Early	163 (96.4)
Delayed	6 (3.6)
Airway assessment	
Normal	128 (75.7)
Unexpected difficult intubation	17 (10.1)
Suspected difficult intubation	24 (14.2)
Use of capnometer	
Not available in the case	36 (21.3)
Presented during intubation period	109 (64.5)
Omitted	24 (14.2)
Nature of practice	
Training	94 (55.6)
Non-training	75 (44.4)
Frequency of EI in each case	
1	145 (85.8)
2	19 (11.2)
3	3 (1.8)
>3	2 (1.2)
Outcomes	
Oxygen desaturation	23 (13.6)
Bradycardia	5 (3.0)

EI = esophageal intubation

Table 2. Incident-related factors and preventability considered by reviewers (n = 169)

Factors or outcomes	n (%)
Incident-related factor	
Patient	46 (27.2)
Surgical	2 (1.2)
Anesthetic	147 (87.0)
Preventability	
Preventable	149 (88.2)
Unpreventable	20 (11.8)
Human errors	
Rule-based	9 (5.3)
Knowledge-based	79 (46.7)
Skill-based	64 (37.9)
Combination	4 (2.4)
Surgical Safety checklist may prevent	10 (5.9)

Table 3. Model of occurrence of EI incidents

Factors	n (%)
Contributing factors	
Inexperience/inadequate knowledge	143 (84.6)
Haste	34 (20.1)
Inadequate preanesthetic evaluation	21 (12.4)
Inappropriate decision	20 (11.8)
Monitor not available	15 (8.9)
Inadequate preanesthetic evaluation	10 (5.9)
Others	17 (10.1)
Factors minimizing incident	
Experienced assistant	150 (88.8)
Vigilance	149 (88.2)
Having experience	147 (87.0)
Improvement of training	15 (8.9)
Adequate equipment	13 (7.7)
Comply to practice guideline	11 (6.5)
Others	22 (13.0)
Suggested corrective strategies	
Additional training	130 (76.9)
More equipment	29 (17.2)
Improved supervision	22 (13.0)
Guideline practice	18 (10.7)
Equipment maintenance	6 (3.6)
Others	11 (6.5)

Discussion

We reported 169 (8.45%) EI incident from the first 2,000 incidents of the PAAd Thai Study[6]. This study reflected that EI is not only a historically persistent problem, but it is still common in anesthesia practice in Thailand. According to American Society of Anesthesiologist [ASA] closed claims project, the authors reported that 14% of respiratory claims is EI. Most of the patient outcomes were death (81%) or permanent brain damage (17%)[1,2]. Since the 1990's, the proportion of EI-related claims decreased to 6% but outcomes were still serious such as high mortality rate or brain damage[8,9]. Similarly, the Fourth National Audit Project in the United Kingdom showed 11 cases (4%) of EI resulting in six deaths (64% mortality rate) and one brain injury[10]. In airway-related claims against Canadian anesthesiologists between 1993 and 2003 dataset, nine of 33 claims (27%) were EI in which six cases resulted in death or permanent brain damage[11]. A publication on anesthesia claimed that the dataset from the United Kingdom in 1995 to 2007 revealed four cases (6% of airway claims) of EI incident and high morbidity and mortality rates[12]. In contrast, the Australian Incident Monitoring Study [AIMS] accounted for only 1.75% of all incident reports and only one death[13].

Compared to the Thai Anesthesia Incident Monitoring Study [Thai AIMS][13], a large prospective multi-center study across Thailand in 2007, the incidence of EI from the present study was slightly higher than the Thai AIMS Study (8.5% vs. 5.3%).

Training situation

Intubation is a maneuver that needs practice and is not easy for new anesthetists. The learning curve of trainees for successful intubation varied from 27 to 50 cases. Results of each study depended on experience of subjects (anesthesia residents, interns, and medical students) and definition of success[14-16].

The present study reported that the most common nature of incident is in training 55.6%. Medical students, anesthesia residents, nurse anesthetist trainees were included in this category. Preoperative airway assessment of most cases revealed normal airway examination but that a lack of experience and knowledge were contributing factors. Immediate and long-term outcomes were unremarkable because of the trainer (attending anesthesiologists or senior nurse anesthetists) vigilance. Trainer awareness resulted in prompt correction and treatment. Additional training and improved supervision were suggested to correct and prevent these cases. In addition, practice by experienced nurse anesthetists or anesthesiologists in rushed or emergency situations were related to tracheal tube misplacement in normal airway patients.

We hypothesized that EI in training situations was unpreventable or naturally occurred in some cases despite good supervision and appropriate monitoring.

Difficult airway

The present study revealed that 75.7% of cases were patients with preanesthetic normal airway examination. After EI detection, tracheal tube could be easily placed in the right position (trachea). Similar to the present study, the United Kingdom and Canadian

anesthesia claims datasets revealed that more than half of EI-incident reports did not state "difficult airway"[11,12]. In contrast, the AIMS showed 15 from 35 incidents (42.9%) were not recorded in difficult airway patients.

Forty-one patients (24.3%) in this study were unexpected or suspected difficult intubation, which were gathered from the details of events. The likelihood of EI was higher in this group. The frequency of EI in each case varied from one to six times until successful intubation. One case was reported as "failed intubation". However, there was no report of any cases having long-term undesirable outcomes. Difficult airway was considered to be a risk of EI from our study due to uncertainty of laryngoscopic view and/or clinical confirmation of the tracheal tube position after intubation. Therefore, capnometer monitoring proved highly beneficial among these cases.

End-tidal carbon dioxide monitoring

The rate of end-tidal carbon dioxide monitoring during intubation period in this case series was 64.5%. Among the 169 cases of EI, 90 cases (53.3%) detected EI earlier than the monitor from clinical examinations performed with anesthetist vigilance or awareness. Moreover another 24 cases (14.2%) recorded capnometer use but EI incidents were clinically detected. A possible explanation for this was that some incidents were also detected by clinical signs earlier and some had not used capnometer during intubation despite capnometer availability.

In Thailand, when comparing the THAI study and Thai AIM Study[13,17], the rate of end-tidal carbon dioxide monitoring in overall incidents increased from 19.2% (2005) to 45.7% (2008) and is presently 78.7%, although the Royal College of Anesthesiologists of Thailand declared capnometery as the basic monitoring standard in all Thai general anesthesia cases since 2015. This study reflected the feasibility of improved capnometer use compliance in the near future despite the fact that not all EI is detected by capnometer.

Delayed detection of EI

According to the Thai AIMS Study, the authors collected 44 cases (2.2% of reported incidents) of delayed detection of EI from a database of 85,021 patients who received general anesthesia with tracheal tube (5.2:10,000)[16]. In the present study, there were only six cases (0.3% of reported incidents) relevant to the definition of delayed detection of EI. Incidence was dramatically reduced because capnometer was emphasized for perioperative use in the operating theaters. In addition, the availability of end-tidal carbon dioxide monitoring increased from 15% to 78.3%. Patient outcomes from the present study had no long-term outcomes from brain damage. Moreover, three out of six cases in our study were patients younger than 15 years old. Pediatric patients are considered at risk, which is similar to the previous study[18].

Oxygen desaturation and outcomes

Reported immediate outcomes of the present study were 23 (13.6%) cases of oxygen desaturation and five (3%) cases of bradycardia requiring treatment. All of these cases completely recovered. No brain damage or EI-related death was reported. These morbidity and mortality rates were different from the previous studies, especially in publications in the early 1990's because of capnometer availability[8,11,12]. Even though EI incidents were detected early, pediatric patients and cesarean section had high-risk of rapid oxygen desaturation due to greater oxygen consumption and lower functional residual capacity[18,19].

Difficult intubation (both of suspected and unexpected difficult intubation) was another risk of desaturation. From the analysis of events in the present study, the capnometer was very helpful to detect the misplacement of tracheal tube in cases of uncertain laryngoscopic view obtained or clinical examination in doubt. The sensitivity and specificity of end-tidal carbon dioxide monitoring were 1.0 and 1.0, respectively[4].

Model of occurrence of EI incidents

The authors found that the most common contributing factor of the EI-incidents was inexperience because more than half of the cases occurred in training situations. In addition, other common factors were haste of experienced anesthetic performers, inadequate pre-anesthetic evaluation in cases of undetected suspected difficult intubation, inefficient equipment due to limited difficult airway instrument availability, and inappropriate decision making for difficult airway algorithm.

The three most common factors minimizing incidents were experienced assistant, vigilance, and adequate experience. These factors relate more to the training process of each institution and each individual anesthetic personnel. In the case of difficult airway, factors minimizing incidents were adequate equipment and practice guideline (difficult airway algorithm) compliance.

The present study demonstrated commonly suggested corrective strategies including additional training, more equipment (difficult airway instruments and capnometers), and guideline compliance.

Conclusion

The incidence of EI in Thailand has not decreased in the past decade despite an increase in capnometer availability. However, incidence of delayed detection of EI and undesirable outcomes have dramatically reduced.

Contributing and minimizing incident factors were related to the training process. EI is considered preventable with additional training and experience. On the other hand, in daily anesthesia practice, capnometer should be available in all cases, especially in high-risk for desaturation populations including patients, pregnant women undergoing cesarean section, and those suspected of difficult intubation.

What is already known on this topic?

EI was a common problem during daily anesthetic practice. In Thailand and other studies, the incidence was not rare and there were severe adverse outcomes from delayed detection of EI. Capnometer is the most useful monitoring technique to detect these events early, however, the study of application in clinical situations and related factors in Thailand are limited.

What this study adds?

Although availability of perioperative capnometer was increased across Thailand, the incidence of EI is still common. On the other hand, the incidence of delayed detection of EI and long-term undesirable outcomes has been dramatically reduced. Anesthetic practice with trainees was a related factor and might be unavoidable in some cases but could be improved with additional training and more experience. Vigilance of anesthetists was also considered as a type of monitoring. This study strongly supports the use of capnometer as a mandatory monitoring equipment in Thailand.

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Potential conflicts of interest

None.

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ภาวะใส่ท่อหายใจเข้าหลอดอาหาร: รายงานอุบัติการณ์ 2,000 รายแรกของโครงการศึกษาภาวะแทรกซ้อนของผู้ป่วยที่ได้รับยาระงับความรู้สึกและผ่าตัดในประเทศไทย (PAAd Thai Study)

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ภูมิหลัง: การใส่ท่อหายใจเข้าหลอดอาหารเป็นภาวะแทรกซ้อนที่เกิดได้บ่อยระหว่างการให้ยาระงับความรู้สึกสำหรับการผ่าตัดโดยเฉพาะอย่างยิ่งในระหว่างการฝึกอบรม

วัตถุประสงค์: เพื่อศึกษาปัจจัยนำและกลยุทธ์ในการแก้ไขป้องกันการเกิดภาวะใส่ท่อหายใจเข้าหลอดอาหาร ในโครงการศึกษาภาวะแทรกซ้อนจากการให้ยาระงับความรู้สึกสำหรับการผ่าตัดในประเทศไทยโดยการรายงานอุบัติการณ์

วัสดุและวิธีการ: เป็นการเก็บข้อมูลรายงานอุบัติการณ์เกิดขึ้นระหว่างเดือนมกราคม ถึง ธันวาคม พ.ศ. 2558 ในโรงพยาบาลขนาดใหญ่ 22 โรงพยาบาลจากทุกภูมิภาคของประเทศไทย วิเคราะห์ข้อมูลโดยใช้สถิติเชิงพรรณนา

ผลการศึกษา: มีรายงานผู้ป่วยที่เกิดภาวะใส่ท่อหายใจเข้าหลอดอาหาร 169 ราย (ร้อยละ 8.45 ของฐานข้อมูล PAAd Thai) ซึ่งเกิดอุบัติการณ์การวินิจฉัยภาวะใส่ท่อหายใจช้าจนผู้ป่วยออกซิเจนต่ำกว่า 85% หรือจนผู้ป่วยเขียวในอัตรา 0.28:10,000 ภาวะการใส่ท่อหายใจยากพบได้บ่อยในกรณีระหว่างการฝึกอบรม (55.6%) โดยส่วนใหญ่วินิจฉัยได้โดยการวินิจฉัยทางคลินิกมากกว่าการวินิจฉัยด้วย capnometer ปัจจัยอื่นที่พบ ได้แก่ ในผู้ป่วยเด็กและหญิงตั้งครรภ์ที่รับการผ่าตัดคลอดเด็กทางหน้าท้อง ภาวะใส่ท่อหายใจยาก ผลลัพธ์ที่พบ ได้แก่ ภาวะระดับความอิ่มตัวของออกซิเจนต่ำ และภาวะหัวใจเต้นช้า

สรุป: อุบัติการณ์การเกิดภาวะใส่ท่อหายใจเข้าหลอดอาหารในประเทศไทยในปัจจุบันลดต่ำลง รวมทั้งอุบัติการณ์ของการวินิจฉัยการใส่ท่อหายใจเข้าหลอดอาหารช้าจนเขียวหรือระดับออกซิเจนต่ำลดลงอย่างมาก เนื่องจากสามารถวินิจฉัยทางคลินิกและหรือวัดด้วยเครื่องวัดระดับความอิ่มตัวของคาร์บอนไดออกไซด์ในลมหายใจออก (capnometer) ได้รวดเร็วขึ้น กลยุทธ์ที่แนะนำสำหรับการแก้ไขและลดอุบัติการณ์ได้แก่ ความรอบคอบระแวดระวัง การฝึกอบรมบุคลากรเพิ่มขึ้น และการจัดหาเครื่องมือเพิ่มขึ้น