Delayed Detection of Esophageal Intubation : Thai Anesthesia Incidents Study (THAI Study) Database of 163,403 Cases

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Introduction: *Even though esophageal intubation is a common event in anesthesia practice, frequently it is easily detected and resolved. However delayed detection of esophageal intubation (DDEI) can lead to many serious adverse events such as severe hypoxemia, cardiac arrhythmia, cardiac arrest and brain death.*
Objectives: *To analyze the incidence of DDEI during general anesthesia with endotracheal intubation and to identify its risk factors, especially patients factors and anesthetic techniques, as well as suggested strategies to prevent it.*
Design: *Prospective observational study.*
Material and Method : *All reported DDEI incidents were identified from the Thai Anesthesia Incidents Study (THAI Study) database conducted between February 1, 2003, and January 31, 2004. Data were analyzed by using descriptive statistics.*
Results: *Forty four cases of DDEI were reported from total of 85,021 cases underwent general anesthesia with endotracheal intubation (5.2: 10,000). The incidence was highest in tertiary care hospital (11.6:10,000). Infant patients (≤ 1 year of age), emergency operation and technique of rapid sequence induction with cricoid pressure were identified as risk factors of DDEI. Detection of DDEI was mainly based on clinical examination. The incidents with extremely low SpO_2 level were reported but most of them were adequately managed without long term consequences and only one patient suffered from severe permanent brain damage.*
Conclusion: *The overall incidence of DDEI in Thailand was 5.2:10,000. Contributing factors included infant patients, emergency operation, and rapid sequence induction with cricoid pressure. Increased awareness and additional training are suggested as preventive strategies.*

Keywords: *Esophageal intubation, Delayed detection, Complications, Outcomes, Incidents, Hypoxemia*

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Esophageal intubation is not uncommon in everyday practice of anesthesia, especially in training center. If it is detected and resolved promptly in reasonable time period, long-term effect might not be expected. However if it is left undetected, it can lead to devastating outcomes and lawsuits. Early detection of esophageal intubation requires reliable and sensitive detecting equipment combined with, more important, anesthesia personnel s vigilance. Preoxygenation can blind the hypoxic response for several minutes after esophageal intubation[1,2]. Thus oxygen saturation in this situation is not sensitive for early detection of esophageal intubation[3-6]. In Thailand, monitoring of carbon dioxide is not routinely included in standard practice. Therefore, early detection of esophageal intubation relies on clinical evaluation of endotracheal position by mean of listening to breath sound at chest wall and stomach area and observation of chest movement which is clearly different from developing country as it is based mainly on the awareness and experi-

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ences of the person who performs intubation rather than equipment.

The objectives of this study were to determine the incidence of delayed detection of esophageal intubation (DDEI) reported in The Thai Anesthesia Incidents Study (THAI Study). We also analyzed clinical risk factors, contributing factors, outcomes and suggested corrective strategies .

Material and Method

The Thai Anesthesia Incidents Study (THAI Study) is a multi-center study including seven university hospitals, five tertiary care hospitals, four secondary care hospitals and four district hospitals. We monitored the adverse events between 1 February 2003 and 31 January 2004 in the registry process of every anesthetic services. Details of preanesthetic conditions, anesthetic managements, intraoperative events and perioperative complications of consecutive patients within 24 hours were recorded in standardized form.

Delayed detection of esophageal intubation (DDEI) was defined as esophageal intubation event which was detected late until hypoxia, clinical cyanosis or pulse oximeter reading of less than 85%, was developed. The details of each event in time frame format were recorded by attending anesthesiologists or nurse anesthetists. Principle investigators or site managers were responsible to complete all record form in details. Each case was reviewed by three reviewers to identify clinical risk factors, contributing factors and corrective strategies. Any controversy was discussed to achieve a consensus. All data of each event were recorded and analysed by descriptive statistics (SPSS version 11.5).

Results

In the database of 163,403 patients in the Thai Anesthesia Incidents Study (THAI Study), there were 86,972 patients who received general anesthesia with endotracheal intubation. Only 85,021 patients that all essential data which included: hospital code, service unit, operative site, age, sex, place, emergency, intubation technique and usage of cricoid pressure) were completed. The total of forty-four cases of DDEI were reported. The incidence was 5.2:10,000 (Table 1). The incidents occurred highest in tertiary care hospitals (11.6:10,000) and lowest in university hospital (2.9:10,000). Male patients were reported more frequent than female. The majority of incidents occurred in patients with ASA physical status of class II, body mass index ≤ 35 and direct intubation technique.

Patient age was range from 3 days to 76 year old with the highest incidence in age group of 1 year or younger (40.9:10,000). The incidence of DDEI varied between age group, emergency situation, and level of hospital (Table 1). The incidence was three time higher when rapid induction and cricoid pressure was used. During the occurrences of DDEI, pulse oximeter and capnography were used only in forty-three and fifteen percents of the patients respectively.

During DDEI, lowest SpO_2 from pulse oximeter varied from 2 to 90 % with mean value of 68.2 ± 21.1 % (Table 2). Estimate duration of esophageal intubation varied from 10 to 60 seconds with median of 30 seconds. Thirty seven patients (84.1%) were diagnosed by clinical examination via observation of chest wall expansion and oscultation of breath sound. Only four patients (9.1%) were detected by capnography.

Management of individual events was evaluated. Twenty- two patients (50%) and thirteen patients (29.5%) were considered to receive perfectly and partially adequate treatment respectively while management of the other nine patients appeared to be inadequate.

DDEI was considered to be preventable in 30 cases (68.2%), partially preventable in 11 cases (25%) and unpreventable in 3 cases (6.8%) (Table 2). All unpreventable cases were patients with large pathological lesion of upper airway. Anesthesia was considered to be sole contributing factors in 22 patients (50%) and combination to other factors in 20 patients (45.5%). Majority of patients with DDEI were completely recovered, both in immediate and long term period (Table 2). Only one patient had brain death after prolonged hypoxia with SpO_2 lowest nearly zero and nearly cardiac arrest.

Considering system analysis, the three most important contributing factors included inadequate care from inexperience(86.4%),equipment malfunction (25%) and lack of supervision (20.5%) (Table 3). The majority of reports which proposed corrective strategies included additional training 39 (88.6%) and quality assurance activities 15 (34.1%).

Discussion

Every outcome study had repeatedly identified adverse respiratory events as a leading cause of injury in anesthesia practice [1-4]. Respiratory related claims was predominantly in the ASA closed claims study [5, 6], and represented one-third of all cases. Three main mechanisms of injury accounted for approximately 75 % of the adverse respiratory events: inadequate

Table 1. Patient characteristics intubating condition, monitoring and sites of sugery

	(n = 44)	Event rate in ratio:10,000
Level of hospital		
University hospital (N = 52,231)	15	2.9
Tertiary care (N = 22,474)	26	11.6
Secondary care (N = 9,312)	3	3.2
Sex		
Male : Female (n)	25: 19	
(%)	56.8: 43.2	
ASA Class 1 : 2 : 3 : 4	11: 24 : 7 : 2	
	ASA 2 = 54.5%	
Age (yr) Range	3 day -76 year	
Mean ± SD	24.19 ± 23.21	
Age group(yr)		
≤ 1 (N = 3,423)	14	40.9
>1 - 8 (N = 5,670)	3	5.3
>8 - 20 (N = 10,936)	6	5.5
>20- 60 (N = 50,339)	19	3.8
> 60 (N = 14,653)	2	1.4
Body weight (Kg) Range	2-95	
Mean ± SD	37.6 ± 28.7	
Body mass index ≤ 35 : > 35	43 :1	
Difficult intubation (n) Yes : No	24 : 20	
Emergency surgery (n) Yes : No	22 : 22	
Intubation technique (n)		
Direct vision : Blind technique	43 : 1	
Rapid sequence induction with cricoid pressure (n)		
Yes (N = 16,434)	17	10.3
No (N = 68,678)	27	3.9
Monitoring equipment available (%)		
Pulse oximeter	43 %	
Capnograph	15 %	
Site of surgery n (%)		
Airway	17 (38.6)	
Abdominal	15 (34.1)	
Intracranial	4 (9.1)	
Extremity	4 (9.1)	
Intrathoracic	2 (4.5)	
Cervical spine	1 (2.3)	
Lumbosacral spine	1 (2.3)	

Value shown as number, ratio, range, mean ± SD and percentages

Table 2. Detail of event management in patient with DDEI

		Number	Percent
Detail of DDEI			
Lowest SpO2 (%)	Range	2-90	
	Mean ± SD	68.2 ± 21.1	
Duration of esophageal intubation (sec)			
	Median (Interquartile range)	30 (10-60)	
Detection by			
	Clinical examination	37	84.1
	Capnography	4	9.1
	Others	3	6.8
Adequacy of event management			
Inadequate & hazard		4	9.1
Inadequate & not hazard		1	2.3
May be inadequate		4	9.1
Partially adequate		13	29.5
Perfectly adequate		22	50.0

Value shown as number, ratio, range, mean ± SD and percentages

ventilation (38%), esophageal intubation (18%) and difficult tracheal intubation (17%). More than 80% of adverse events caused by inadequate ventilation and esophageal intubation were reviewed as substandard of anesthetic care [5]. Both high incidences of respiratory adverse events and high payment rate in malpractice suits [5, 6] lead to standard monitoring of pulse oximeter and capnography in anesthesia service in many countries [7, 8].

In anesthesia quality assurance studies, delayed detection of esophageal intubation (DDEI) was not regularly coded as a countable event [9, 10]. DDEI is one of the most important underlying causes of desaturation, pulmonary aspiration, unstable hemodynamic, cardiac arrhythmia, cardiac arrest, death or brain damage. Prospectively obtaining all severe adverse events happening in peri-intubation period is a more reliable way to identify DDEI than regular data collection in quality assurance process alone. In this study, both regular data collection and voluntary report of DDEI were used to gathering all cases of DDEI. Incidence of DDEI was 5.2:10,000 in technique of general anesthesia with endotracheal intubation. This incidence was significantly lower than other studies [11-14] of emergency tracheal intubation for critically ill patients both inside and outside hospital area by professional and non-professional personnel. Their incidences were range between 6-16 % of all emergency intubation which represent one hundred percent higher than our study. However, it should be noted that the definitions of esophageal intubation were different. We identified only when misplacement of endotracheal tube into esophagus was the cause of significant hypoxia.

Incidence of DDEI in tertiary hospital was three times higher than in university hospital. In tertiary care hospital, capnography was used less frequent than in university hospital (10% VS 25.3%) and nurse anesthetists were responsible as first intubators ten times more frequent than in university hospital (68.3% VS 6.8%). These two factors could be associated with higher incidence of DDEI in tertiary care hospital.

In our study, age was found to be one of the most important patient-related risk factors for DDEI. The incidence was highest in infant patients (≤ 1 year, incidence = 40.9:10,000). This could reflect of inadequate experience of trainees, nurse anesthetists, and anesthesiologists in handling small children probably due to limited exposure to this group of patients.

The rapid sequence induction and intubation with cricoid pressure used for prevention of gastric regurgitation and pulmonary aspiration was also found to be a technical risk for DDEI. The application of cricoid pressure creates pressure in laryngeal structure and upper airway. This may cause more difficulty to apply tip of laryngoscope blade into good position and also limit exposure of true vocal cord. Passing of endotracheal tube becomes more difficult and easily

Table 3. Preventability of anesthesia related to DDEI : level of anesthesia contributed to the event, outcomes, contributing factors and corrective strategies

	Number (%)	
Preventability		
Preventable	30 (68.2)	
Partially preventable	11 (25.0)	
Unpreventable	3 (6.8)	
Level of anesthesia contributed to the event		
Anesthesia only	22 (50)	
Combination factors	20 (45.5)	
Underlying disease	2 (4.5)	
Outcome	**Immediate**	**Long term**
Complete recovery	38 (86.4)	42 (95.5)
Minor effect	5 (11.4)	0
Major effect	0	1 (2.3%)*
Not stated	1	
Contributing factors		
Human failure		
Presence	7 (15.9)	
Knowledge - Improper intubation technique	8 (18.2)	
Inadequate care		
Inadequate preoperative evaluation	6 (13.6)	
Inexperience	38 (86.4)	
Fatigue	0 (0)	
Communication failure	1 (2.3)	
Lack of supervision	9 (20.5)	
Equipment failure		
Presence	4 (9.1)	
Function	11 (25)	
Corrective strategies		
Guideline practice	9 (20.5)	
Additional training	39 (88.6)	
More man power	2 (4.5)	
Improved supervision	8 (18.2)	
Equipment maintenance	3 (6.8)	
Quality assurance activity	15 (34.1)	

Value shown as number (%)

leads to esophageal intubation. This study demonstrated that allocation of rapid sequence induction and intubation with cricoid pressure increased the incidence of DDEI from 3.9:10,000 to 10.3:10,000 (Table 1). This confirmed the study of patient morbidity from esophageal intubation by Mort TC [14] which demonstrated that the application of cricoid pressure did not decrease the risk of aspiration but significantly increased risk of esophageal intubation.However, cricoid pressure is suggested technique in standard guideline during induction and intubation for patient at risk of aspiration[15] . However, trained and experienced assistant is needed to apply appropriate pressure for intubation.

In our study, DDEI was mostly detected by clinical examination (84 % of cases) which showed that reliability and validity of clinical examination by nurse anesthetists and anesthesiologists was reasonably high. Nevertheless, in patients at risk such as infants,

predicted difficult intubation, upper airway lesion, obesity, clinical examination alone may not guarantee patient safety. Capnography is advisable in these situations as it has been suggested to improve DDEI detection [16].

Capnograph is not always reliable for detection of esophageal intubation in small children because of low tidal volume [17]. Hsieh [18] studied the usage of ultrasound image of bilateral diaphragm movement for the confirmation of endotracheal position in pediatric intensive care unit. They could identify not only all esophageal intubation but also endobronchial intubation. The usage of esophageal detector device [19] is debatable due to possible false negative result which leads to wrong confirmation and delayed decision.

Nearly eighty percent of our case series, management of DDEI were considered to be perfectly or partially adequate. Only one patient developed permanent brain damage due to prolonged hypoxia. Our final outcomes were much better than other studies [10, 11, 13, 14, 20] which may be because their patients were more critically ill and our patients airway management was handled by more experienced personnel.

In summary, this study was the first prospective incidence study of delayed detection of esophageal intubation in anesthesia service in multicenter and national representation. The incidence of DDEI was not high (5.2:10,000 or 0.05%). Awareness and experience of anesthetic personnel were the key performance strongly associated with early detection of esophageal intubation and reduction of DDEI . We suggested to use end tidal carbon dioxide monitoring to confirm endotracheal tube position in every patient with high risk situations which includes emergency surgery, usage of cricoid pressure, infant patients and expected difficult intubation.

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ภาวะใส่ท่อหายใจเข้าหลอดอาหารที่ตรวจพบได้ช้า : จากฐานข้อมูลของ Thai Anesthesia Incidents Study จำนวน 163,403 ราย

ฐิติมา ชินะโชติ, สุวรรณี สุรเศรณีวงศ์, วิโรจน์ เพ่งผล, ทรงยศ วลัยฤาชา

ที่มาและเหตุผล: *ภาวะใส่ท่อหายใจเข้าหลอดอาหารระว่างการให้ยาระงับความรู้สึก ส่วนใหญ่ตรวจพบได้ง่าย และมักแก้ไขได้ทัน แต่การตรวจพบภาวะใส่ท่อหายใจเข้าหลอดอาหารได้ช้า (DDEI) ทำให้เกิดภาวะแทรกซ้อนร้ายแรงเช่น ภาวะขาดออกซิเจนรุนแรง หัวใจเต้นผิดจังหวะ หัวใจหยุดเต้น หรือสมองถูกทำลาย*

วัตถุประสงค์: *เพื่อวิเคราะห์หาอุบัติการณ์ของ DDEI ระหว่างการให้ยาระงับความรู้สึกที่ใส่ท่อหายใจ และประเมินผู้ป่วยกลุ่มเสี่ยง ตลอดจนโอกาสเสี่ยงจากเทคนิคการให้ยาระงับความรู้สึก พร้อมทั้งวิธีการป้องกัน หรือลดอุบัติการณ์เกิด DDEI*

วัสดุและวิธีการ: *เป็นการศึกษาแบบเก็บข้อมูลไปข้างหน้า ศึกษาข้อมูลผู้ป่วยที่ตรวจพบภาวะใส่ท่อหายใจเข้าหลอดอาหารได้ช้าจนทำให้เกิดภาวะขาดออกซิเจนรุนแรงระว่างการให้ยาระงับความรู้สึกซึ่งคัดเลือกมาจากข้อมูลการศึกษาของราชวิทยาลัยวิสัญญีแพทย์แห่งประเทศไทย ซึ่งรวบรวมตั้งแต่ กุมภาพันธ์ พ.ศ. 2546 ถึง มกราคม พ.ศ. 2547 นำมาวิเคราะห์ทางสถิติเชิงพรรณนา*

ผลการศึกษา: *พบภาวะ DDEI 44 ราย ในจำนวนผู้ป่วยที่ได้รับการให้ยาระงับความรู้สึกที่ใส่ท่อหายใจจำนวน 85,021 ราย (5.2:10,000) พบอุบัติการณ์สูงที่สุดในโรงพยาบาลระดับตติยภูมิ (11.6:10,000) โอกาสเกิด DDET พบสูงในผู้ป่วยทารก (อายุ<_1 ปี) การผ่าตัดฉุกเฉิน การใช้เทคนิค rapid sequence induction with cricoid pressure การตรวจพบ DDEI อาศัยการตรวจพบทางคลินิกเป็นหลัก ส่วนใหญ่ได้รับการแก้ไขทันท่วงที พบผู้ป่วย 1 ราย ที่มีภาวะสมองถูกทำลายรุนแรง*

สรุป: *อุบัติการณ์เกิด DDEI เท่ากับ 5.2: 10,000 ปัจจัยเสี่ยงได้แก่ ทารก (อายุ<_1 ปี) การผ่าตัดฉุกเฉิน การใช้เทคนิค rapid sequence induction with cricoid pressure ความระแวดระวังรวมทั้งการฝึกหัดเพิ่มเติมในการใส่ท่อหายใจและการตรวจสอบภาวะ DDEI จะช่วยลดอุบัติการณ์ได้*