Multicentered Study of Model of Difficult Endotracheal Intubation by Incident Reports from University and Non-University Hospitals

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Objective: *To compare the characteristics, causative factors, outcomes, prevention, and suggested preventive strategies of difficult intubation between university (U) and general community (non-U) hospitals.*
Material and Method: *One thousand nine hundred and ninety-six reports were reviewed from Thai anesthesia incident monitoring study (Thai AIMS) conducted in 51 hospitals nationwide between January and June 2007. Thirty-four cases of DI were reported from U hospitals and 69 cases from non-U hospitals. The described details on each report on difficult intubation (DI) in adults undergoing general anesthesia were thoroughly reviewed by three reviewers to give their consensus opinions on causative factors, outcomes, contributing preventive factors, and strategies for corrections. Descriptive statistics were used for data analysis.*
Results: *Patient factors were the most common cause of DI (88% in U and 87% in non-U hospitals). Fifty percent of U and 51% of non-U DI cases were consequences of human errors, which were preventable and mostly based on knowledge (88% vs. 71%) and rules of practice (23% vs. 51%). Substitution of an intubating anesthesiologist, reducing the size of endotracheal tubes, and stylet guided technique were the three commonly used methods after DI. MacCoy laryngoscope, fiber optic-aided intubation, laryngeal mask airway, and Frova introducer were commonly used as substitutes for the standard laryngoscope. Inadequate experience was the major problem of U hospitals, which required additional training to gain more skill. The most common problem of DI in non-U hospitals was inadequate preanesthetic evaluation. Therefore, they required practice guidelines and experienced assistants in difficult situations.*
Conclusion: *Half of DI cases were preventable. DI cases in Non-U hospitals were mostly caused by inadequate preanesthetic evaluation. This indicates the necessities of providing practice guidelines and experienced assistants. In U hospitals, in-training practice of intubation should be performed under supervision. More advanced substitution techniques were applicable in U hospitals.*

Keywords: *Difficult intubation, Adverse events, Complication, Incident report, Guidelines, Patient safety*

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The Royal College of Anesthesiologists of Thailand (RCAT) set up a national collaboration to do a multicentered study of anesthesia related adverse events in 20 hospitals across Thailand. This was done by registry technique for reporting unusual or undesirable events during the 163,493 anesthesia over the 12-month period between February 2003 and January 2004[1,2]. Following a previous THAI Study, nationwide incident monitoring was conducted to study multicentered models of anesthesia related adverse events

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in Thailand by incident report (Thai AIMS)[3]. This will provide very useful data of all over the country, which is a useful tool to make a notice for quality improvement and maintenance of high safety standards in anesthesia practice in Thailand. Difficult intubation (DI) is one of the most serious incidents that could lead to major organ damage or fatal outcome[4]. Since Thailand has a shortage of anesthesiologists, most anesthesia, especially in community hospitals was performed by nurse anesthetists or general medical doctors who have limited experience in intubation and airway management. Moreover, some areas still have insufficient medical assistants in anesthesia works. Since the different strategies of problem approach might be needed, the authors collected prospective voluntary and anonymous incident reports from 51 Thai hospitals, which included community hospitals, general hospitals, and tertiary hospitals[3].

The objectives of the present study were to study the characteristics of DI events, compared between university hospitals (U) and general or community hospitals (non-U) for causative factors, outcomes after the incidents, and prevention and successful techniques including minimizing and corrective strategies of DI.

Material and Method

After being approved by each institutional ethical committee, the present study was prospectively conducted in 51 hospitals within six months (between January and June 2007)[3]. Ten of these were university hospitals (60-2,400 beds) and the other 41 were primary to tertiary hospitals (30-1,200 beds) under the ministry of public health and ministry of defense. Before starting to collect the data, several workshops were held for participants and they were instructed to observe the anesthesia incidents and then make incident reports. All participants were asked to fill out a standardized incident report form within 24 hours after they experienced adverse or undesirable events. After receiving each report, those completed forms were reviewed by the site-manager and sent to the data management center. After checking and standardizing the keywords, the data form was put on the central computerized database.

Finally, 1,996 cases of incident reports and 2,537 incidents were collected during the 6-month study period. The enrolled data reports were reviewed by three reviewers who had expertise in intubation. They identified and selected all cases of difficult intubation in adult patients scheduled to receive general anesthesia that required endotracheal intubation, in elective as well as emergency situations, which included abdominal, vascular, urologic, and endocrinologic surgery. Patients aged < 15 years, undergoing oral surgery or pregnancy were excluded from the present study. As a result, 103 patients, 34 from university (U) and 69 non-U hospitals were enrolled. The described details on all the reported forms were studied, which included what, where, when, and how the incidents happened. Reported hemodynamic changes regarding the incident, causative factors, possibilities of human error, immediate and long-term outcomes of the patients after DI were reviewed. The reviewer collected all of the given data. All the reviewers blindly committed revision in all details and made consensus on contributing factors, factor-minimizing incidents, and suggested corrective strategies. Any disagreement was critically discussed and judged to achieve a consensus. The descriptive statistics were used to summarize the data by using SPSS for Windows version 12.

Results

During the 6-month period, there were 1,996 reported cases of anesthesia incidents from 10 U and 41 non-U hospitals. There were 34 cases and 69 cases of difficult intubation from U hospitals and non-U hospitals reported to the data management unit. The administrative characteristic of both types of hospitals are shown in Table 1.

Table 1. Administrative characteristics of studied hospitals

	University (n = 10)	Non-university (n = 41)
No. of patient beds	10,264	20,133
No. of anesthesiologists	174	109
No. of In-training or general doctors	191	262
No. of nurse anesthetists	270	546
Patient beds per anesthesia provider	16.2:1	21.9:1

Number of cases, patients characteristics, contributing factors and preventability of DI are shown in Table 2. Factors affecting the DI were mainly from patient factor (88 and 87% of DI cases of U and non-U respectively). Additionally, anesthetic and systemic errors were also common, which crucially require quality assurance and system improvement. Fifty percent of U and 51% of non-U DI cases were the consequences of human errors, which were preventable and mostly based on inadequate knowledge (88% vs.71%) and rules of practice (23% vs. 51%). Substituting an intubating anesthesiologist, reducing the size of the endotracheal tube, and stylet-guided techniques were the common successful steps offering the most assistance of airway establishment, respectively. MacCoy laryngoscope, FOB, LMA, and FROVA were commonly used as substitutes for a standard laryngoscope (Table 3). Outcomes after DI are demonstrated in Table 4. There was one fatal case of fatal case. The summaries of unplanned ICU admissions are:

Patient I: Four attempts of intubation with 7.5, 7.0 and 6.5 gauge endotracheal tubes were not successful. Another failure was found by awake blind nasal intubation and followed by FOB-aided successful intubation. Vocal cords were swelling with a large amount of airway secretion.

Patient II: Three attempts of intubation, a 70-year-old patient developed AF with RVR and cardiac arrest at 15 hours postoperatively.

Table 2. Numbers, proportions and causative factors of difficult intubation

	University (n = 34)	Non-university (n = 69)
Mallampati 3,4 and/or TMD < 5 cm	14 (41%)	32 (46%)
Mallampati1,2 and TMD ≥ 5 cm	20 (59%)	37 (54%)
Patient factors	30 (88%)	60 (87%)
Surgical factors	1 (3%)	1 (2%)
Anesthetic factors	13 (38%)	30 (44%)
System errors	6 (18%)	24 (35%)
Non-preventable (% of total)	17 (50%)	34 (49%)
Human errors (preventable) (% of total)	17 (50%)	35 (51%)
Ruled base (% of preventable)	4 (23%)	18 (51%)
Knowledge based(% of preventable)	15 (88%)	25 (71%)
Skill based (% of preventable)	1 (5%)	1 (3%)

Value shown as number (%)

Table 3. Technique and airway devices for successful airway establishment

	University (n = 34)	Non-university (n = 69)	Total (n = 103)
Techniques			
Substituting personnel	11 (32.4%)	31 (44.9%)	42 (40.8%)
Reduced ET size	9 (26.5%)	25 (36.2%)	34 (33.0%)
Stylet	6 (17.6%)	19 (27.5%)	25 (24.3%)
Awake intubation	1 (2.9%)	8 (11.6%)	9 (8.7%)
Oral to nasal / nasal to oral	1/1 (5.9%)	0	1/1 (1.9%)
Repositioning	1 (2.9%)	0	1 (0.9%)
Airway devices			
McCoy laryngoscope	6 (17.6%)	10 (14.5%)	16 (15.5%)
FOB	5 (14.7%)	6 (8.7%)	11 (10.7%)
LMA	3 (8.8%)	2 (2.9%)	5 (4.9%)
Frova Introducer	4 (11.8%)	0	4 (3.9%)
Retrograde technique	0	1 (1.4%)	1 (1.0%)

Value shown as number (%)

Patient III: After three attempts of intubation, hypotension, severe bowel distension, and suspected esophageal rupture.

Patient IV, V: Vocal cord swelling following several intubation attempts by standard laryngoscope with guide wire, three intubation attempts with MacCoy laryngoscope, five FOB-aided, and five blind nasal intubation. Surgeon postponed the case.

Patient VI: Vocal cord swelling and dental injury with major physiological change (hypoxia).

Patient VII: After three attempts, patient developed hypertension, SVT (heart rate 130-150) and suspected bowel rupture.

According to the reviewers' opinions, the three common causes of DI of U hospitals were inadequate experience, insufficient evaluation, and inappropriate decision. Differently, insufficient evaluation was the most causative factor in non-U hospitals (Table 5). The foremost suggestions to minimize the incidents were having previous experiences, following with experienced assistants, and high awareness of DI, whereas the presence of experienced assistants was mainly suggested in the non-U group (Table 6). Additional training was the most commonly suggested strategy by the U group to lessen the incidents while the non-U group needed guideline practice, followed by additional training and quality assurance (Table 7).

Discussion

Recently, the THAI Study has provided national numerical incidents or adverse outcomes. The data showed the figure of DI was 234 from 163,403 anesthesia (0.14%) during February 2003 to January 2004 (THAI Study)[5]. The next step of the studies was focused on the 1,996 voluntary incident reports from 51 hospitals across the country (Thai AIMS)[3,6]. The following step was the incident analysis of different

Table 4. Outcomes after difficult intubation

Adverse outcomes	Number of cases (%)	
	University (n = 34)	Non-university (n = 69)
Major physiologic change	5 (14.7%)	18 (26.1%)
Minor physiologic change	2 (5.9%)	7 (10.1%)
Unplanned ICU	2 (5.9%)	5 (7.2%)
Cancellation and postpone	0	3 (4.3%)
Awareness	1 (2.9%)	0
Prolonged ventilation support	1 (2.9%)	0
Death	0	1 (1.4%)

Table 5. Contributory factors that may relate to difficult intubation

Contributory factors	Number of cases (%)		
	University (n = 34)	Non-university (n = 69)	Total (%) (n = 103)
Inadequate experience	17 (50%)	26 (37.7%)	43 (41.7%)
Insufficient Evaluation	8 (23.5%)	32 (46.4%)	40 (38.8%)
Inappropriate decision	7 (20.6%)	19 (27.5%)	26 (25.2%)
Inadequate patient preparation for intubation	4 (11.8%)	8 (11.6%)	12 (11.7%)
Inadequate knowledge	3 (8.8%)	9 (13.0%)	12 (11.7%)
Emergency situation	3 (8.8v)	4 (5.8%)	7 (6.8%)
Inadequate airway instruments	2 (5.9%)	5 (7.2%)	7 (6.8%)
Malfunction of instruments	3 (8.8%)	3 (4.3%)	6 (5.8%)
Exhausted personnel	1 (2.9%)	3 (4.3%)	4 (3.9%)
Inadequate personnel	1 (2.9%)	2 (2.9%)	3 (2.9%)
No monitoring	0	3 (4.3%)	3 (2.9%)

Table 6. Factors minimize incidents of difficult intubation

Minimizing factors	University hospital (n = 34)	Non-university hospital (n = 69)	Total (%) (n = 103)
Having previous experience	25 (73.5%)	47 (68.1%)	72 (69.9%)
Experienced assistants	12 (35.3%)	50 (72.5%)	62 (60.2%)
High awareness	11 (32.4%)	38 (55.1%)	49 (47.6%)
Adequate instruments	4 (11.8%)	7 (10.1%)	11 (10.7%)
Guidelines	4 (11.8%)	3 (4.3%)	7 (6.8%)
Good communication	1 (2.9%)	6 (8.7%)	7 (6.8%)
Adequate monitoring	1 (2.9%)	4 (5.8%)	5 (4.9%)
Consultation availability	2 (5.9%)	2 (2.9%)	4 (3.9%)
Improve training system	2 (5.9%)	2 (2.9%)	4 (3.9%)
Instrument calibration and checking	2 (5.9%)	2 (2.9%)	4 (3.9%)
Substituting personnel	1 (2.9%)	3 (4.3%)	4 (3.9%)
Maintenance of equipments	1 (2.9%)	3 (4.3%)	4 (3.9%)

Values shown as number (%)

Table 7. Suggested corrective strategies for difficult intubation

Suggested strategies	Number of cases (%)		
	University (n = 34)	Non-university (n = 69)	Total (%) (n = 103)
Additional training	18 (52.9%)	23 (33.3%)	41 (39.8%)
Guideline practice	10 (29.4%)	28 (40.6%)	38 (36.9%)
Quality assurance activity	8 (23.5%)	23 (33.3%)	31 (30.1%)
Improved supervision	5 (14.7%)	20 (29.0%)	25 (24.3%)
More equipments	6 (17.6%)	9 (13.0%)	15 (14.6%)
More manpower	1 (2.9%)	6 (8.7%)	7 (6.8%)
Equipment maintenance	1 (2.9%)	1 (1.4%)	2 (1.9%)
Good referral system	0 (0%)	1 (1.4%)	1 (1.0%)

Values shown as number (%)

adverse outcomes by getting through the details of each reported event. By voluntary reporting, the authors got many important details that included the causative factors and suggested strategies to prevent those undesired outcomes.

As a university hospital, both human and instrument resources were more available, compared to non-U hospitals. Therefore, the authors aimed to point out the presence of different problems between these two types of hospitals so that corrective strategies should be set up appropriately according to each group.

Comparing the proportion of patient beds per anesthetic provider, included anesthesiologists or non-anesthesiologists, non-U hospitals was lower than U hospitals (21.9:1 vs. 16.2:1). This indicates that the anesthetic workload of non-U personnel might be more. If the authors use only the number of patient beds per anesthesiologists as a bench marking, the authors found non-U hospital of 103:1 (20,133:195) and U of 69:1 (12,064:174)[3]. It is obvious that a shortage of anesthesiologists in Thailand is an urgent problem that needs to be solved by a national policy to increase specialized training in anesthesia.

All the records were anonymously reviewed by three experts, not only from the designed record form, but also from the descriptions in detail of the event. The consensus about the adverse outcomes, successful intubation techniques, and causative and corrective factors were determined thoroughly in many perspectives.

Preoperative evaluation is important in the detection of patients at risk for difficult airway management by noting anatomical landmarks and

clinical factors associated with a difficult airway[4]. The recorded data from the Thai AIMS study included only the oropharyngeal volume, as defined by modified Mallampati score and thyromental distance (TMD) for prediction of difficult airway[7,8]. By these two tests for DI detection, the number of the DI cases was underestimated by two-thirds (59% from 88% in U hospitals, and 54% from 87% in non-U hospitals). These figures included DI cases in which the airway assessments were not performed preoperatively. However, Krobbuaban et al showed the ratio of height and thyro-mental distance as a predictive test for DI prediction in Thai people[9]. In half of the patients, it is obvious that DI could be avoided. Thus, preoperative evaluation of the airway should be encouraged as a useful means of achieving more accurate predictions of DI, especially for those unskilled personnel. Preoperative airway assessment must be involved in the quality assurance and clinical practice guidelines. The increased awareness of DI would be alerted and better prepared of experts and alternative airway devices. Other airway assessments, e.g. cervical mobility, interincisive distance, and neck circumference might also be supplemented in the preoperative evaluation and record form[4,10].

The authors found that the consequences of DI were more common and more severe in non-U hospitals. These included major and minor physiologic changes, unplanned ICU admissions, and case cancellation. During the study course, the authors found one case of severe pneumonitis that was followed by death in a non-U hospital. The consequence during and post DI might have direct or indirect influence on the fatal outcome. All these results reflect the limitations of skilled performance in such a difficult emergent situation. Among the ICU patients, a higher rate of immediate and severe life-threatening complications might be found more than expected in DI because of their impending multi-organ dysfunction[11].

Experienced consultants or assistants were actually and promptly needed and could overturn the morbidity and mortality rate. In U hospitals, DI still commonly occurred because of unskilled training-personnel. Their training procedures were all performed under supervision of experienced U hospital staff and with more innovative airway devices such as FOB, special types of laryngoscopes, and others. Many intubation techniques were previously reported as preferable and effective, such as fiber-optic-aided intubation, bougie, Frova introducer[12], LMA, intubating LMA, and Wuscope, etc. During the reviewed period of the present study, intubation with MacCoy laryngoscope was the most frequent approach technique, especially in unanticipated DI in non-U hospitals because it is more available and simple. FOB-aided intubation was limitedly performed because it requires a greater degree of skill compared to many other techniques[13]. Training and practice are required and should be performed only if the anesthesia care provider is able to maintain adequate oxygenation and ventilation until the airway is secured.

Surprisingly, some other intubation techniques, other than FOB, were very limitedly used. The problems of shortages of novel techniques or instruments must be focused and require national policies of providing skill training workshops and novel instruments techniques.

According to the present study, complications from those hospitals had been reported voluntarily and anonymously. The reporting process was motivated by incentives to improve the compliance of anesthesia practice. Their opinions about the influenced factors and their suggestions would point out national policies of anesthesia improvements.

Up until now, a shortage of anesthesiologist has been a continuing problem of Thailand, especially in non-U hospitals. Anesthesia works is mostly done by nurse anesthetists. Therefore, continuing medical education and workshops on updated and advanced alternative intubation techniques should be regularly conducted to maintain skilled performance and advanced knowledge. National survey and quality assurance to standardize the practice should be thoroughly considered. Pitimana-Aree et al surveyed the awareness, opinion and reported use of clinical practice guidelines (CPG) of the Royal College of Anesthesiologists of Thailand among the members and found a low level of awareness and poor implementation and dissemination in their practice[14]. Accordingly, the national authorities should strongly promote and encourage the members to comply and adhere to the guidelines designed to improve the quality of patients' care.

In conclusion, DI is usually followed by many serious hemodynamic or even fatal outcomes. Half of these events were preventable, but complicated situations still occur mostly because of human errors. For daily practice, reducing the incidents of DI by airway evaluation and good preparation for possible difficulties in endotracheal intubations are absolutely necessary. In U hospitals, training of standard and adjuvant techniques of intubation should be performed under

supervision. For other community hospitals, practice guidelines, having expertise consultants, and improving their own individual skills, were crucially needed. All difficult situations should be minimized and prevented to improve safety in anesthesia practice.

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การศึกษาแบบจำลองการเกิดภาวะใส่ท่อหายใจยากในโรงพยาบาลมหาวิทยาลัย และโรงพยาบาลซึ่งมิได้สังกัดมหาวิทยาลัย โดยการรายงานอุบัติการณ์

เกศชาดา เอื้อไพโรจน์กิจ, ธารทิพย์ ประณุทนรพาล, ยอดยิ่ง ปัญจสวัสดิ์วงศ์, สุรศักดิ์ ถนัดศีลธรรม, ศิริลักษณ์ ชำนาญเวช, วิรัตน์ วศินวงศ์, วิโรจน์ เพ่งผล

วัตถุประสงค์: *เพื่อศึกษาลักษณะการเกิด สาเหตุ ผลลัพธ์ การป้องกัน และแนวทางป้องกันภาวะใส่ท่อหายใจยากในกลุ่มโรงพยาบาลมหาวิทยาลัยและโรงพยาบาลซึ่งมิได้สังกัดมหาวิทยาลัย*

วัสดุและวิธีการ: *จากรายงานอุบัติการณ์ภาวะแทรกซ้อนจากโรงพยาบาล 51 แห่ง ทั่วประเทศไทย ระหว่างเดือนมกราคม ถึง เดือนมิถุนายน พ.ศ. 2550 โดยมีจำนวนผู้ป่วยทั้งหมด 1,996 ราย วิสัญญีแพทย์ผู้เชี่ยวชาญทำการทบทวนผู้ป่วยที่ได้รับการวินิจฉัยภาวะใส่ท่อหายใจยากตามคำจำกัดความจำนวน 34 ราย ในโรงพยาบาลมหาวิทยาลัยและ 69 รายในโรงพยาบาลที่มิได้สังกัดมหาวิทยาลัยในการวิเคราะห์สาเหตุ ผลลัพธ์ การป้องกันและกลยุทธ์แก้ไข สำหรับภาวะแทรกซ้อนนี้ การวิเคราะห์ใช้สถิติแบบพรรณนา*

ผลการศึกษา: *ภาวะใส่ท่อหายใจยากเกิดจากปัจจัยผู้ป่วยมากที่สุด ร้อยละ 88 และร้อยละ 87 ในโรงพยาบาลมหาวิทยาลัย และโรงพยาบาลที่มิได้สังกัดมหาวิทยาลัย ร้อยละ 50 และร้อยละ 51 ของภาวะแทรกซ้อนเกิดจากความผิดพลาดของมนุษย์ภาวะใส่ท่อหายใจยากในโรงพยาบาลมหาวิทยาลัย และโรงพยาบาลที่มิได้สังกัดมหาวิทยาลัยเกิดจากปัจจัยของตัวผู้ป่วยเอง (88% และ 87% ตามลำดับ) ความผิดพลาดของมนุษย์ (50% และ 51%) ซึ่งเป็นภาวะที่ป้องกันได้ ส่วนใหญ่เกิดจากการขาดความรู้ (88% และ 71% ตามลำดับ) วิธีการจัดการ 3 อย่างที่ทำบ่อยที่สุดได้แก่ การเปลี่ยนบุคลากรผู้ใส่ท่อหายใจ การลดขนาดท่อหายใจ และการใส่แกนแข็งในท่อหายใจ อุปกรณ์ช่วยที่นิยมใช้ได้แก่ เครื่องส่องกล่องเสียงแบบ MacCoy การใช้เครื่องส่องกล่องเสียงแบบ fiberoptic การใช้หน้ากากครอบกล่องเสียงและ Frova introducer การขาดประสบการณ์เป็นสาเหตุใหญ่ในโรงพยาบาลมหาวิทยาลัย ซึ่งแก้ไขได้ด้วยการฝึกอบรมเพิ่มเติม ส่วนการประเมินผู้ป่วยก่อนให้ยาระงับความรู้สึกที่ไม่เพียงพอเป็นสาเหตุใหญ่ในโรงพยาบาลที่มิได้สังกัดมหาวิทยาลัย*

สรุป: *ประมาณกึ่งหนึ่งของภาวะใส่ท่อหายใจยากเป็นภาวะที่ป้องกันได้ การประเมินผู้ป่วยไม่เพียงพอในโรงพยาบาลที่มิได้สังกัดมหาวิทยาลัยอาจแก้ได้ด้วยการปฏิบัติตามแนวทางเวชปฏิบัติและการมีผู้ช่วยที่มีประสบการณ์สำหรับโรงพยาบาลที่มีการฝึกอบรมควรมีผู้ควบคุมที่สามารถให้คำปรึกษาที่ดีและควรจัดหาเครื่องมือพิเศษช่วยสำหรับกรณีใส่ท่อหายใจยาก*