Original Article

Reintubation in the Post-Anesthesia Care Unit [PACU] from the First 2,000 Incidents: Perioperative and Anesthetic Adverse Events in Thailand [PAAd Thai] Study

Ampawan Tanyong MD[1], Prapa Ratanachai MD[2], Somrat Charuluxananan MD[3], Sunida Atichat MD[1], Somchai Agprudyakul MD[4], Chuthamat Somchat MD[5], Duangporn Tanutanud MD[6], Wanida Chongarunngamsang MD[7], Kwankamol Boonsararuxsapong MD[8]

[1] Department of Anesthesiology, Chonburi Regional Hospital, Chonburi, Thailand
[2] Department of Anesthesiology, Hatyai Hospital, Hat Yai, Songkhla, Thailand
[3] Department of Anesthesiology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand
[4] Department of Anesthesiology, Buddhasothorn Hospital, Chachoengsao, Thailand
[5] Department of Anesthesiology, Lamphun Hospital, Lamphun, Thailand
[6] Department of Anesthesiology, Lampang Hospital, Lampang, Thailand
[7] Department of Anesthesiology, Faculty of Medicine, Srinakharinwirot University, Bangkok, Thailand
[8] Department of Anesthesiology, Chiangrai Prachanukroh Hospital, Chiang Rai, Thailand

Objective: To investigate anesthesia-related adverse events focusing on reintubation in the post-anesthesia care unit [PACU] from the Perioperative and Anesthetic Adverse Events in Thailand [PAAd Thai] Study hosted by the Royal College of Anesthesiologists of Thailand.

Materials and Methods: All relevant incident reports of reintubation that occurred in the PACU out of the first 2,000 incident reports from 22 hospitals between January 1 and December 31, 2015 were reviewed by three senior anesthesiologists. Any disagreement was solved by consensus after discussion. Descriptive statistics was used.

Results: There were 107 incident reports of reintubation from the 221 incidents occurring in the PACU. Forty-nine patients (45.9%) and 11 patients (10.3%) were patients with age over 60 years and younger than 10 years. Sixty-four (59.8%) cases were ASA physical status 3 and 4 while higher risk were patients in general, orthopedic, neurological, obstetric & gynecological and urological surgeries. Two-thirds of incidents occurred in service-based hospitals and in emergency condition. Usage of neuromuscular blocking agents (83.9%), midazolam (17.8%), morphine (28%), and fentanyl (73.8%) were considered as anesthesia related factors. Fifty-one percent of patients receiving non-depolarizing muscle relaxant were extubated without reversal agents. Respiratory physiologic changes, particularly oxygen desaturation (37.4%), unplanned ICU admission (33.6%), and prolonged ventilatory support (31.8%) were common outcomes. After reviewing all incidents, patients (66.4%), anesthetic (74.8%), and knowledge-based error (57.9%) were common factors while 52.3% of cases were considered as preventable.

Conclusion: Incidence of reintubation in the PACU dramatically decreased over a decade. Contribution factors were human factors (inappropriate decision making, inadequate preanesthetic evaluation, and inexperience). Factor minimizing incidents were vigilance and having experience. Suggested strategies are improvement of supervision, quality assurance activity, practice guidelines, additional training, and improvement of communication.

Keywords: Reintubation, Failed extubation, Complication, Recovery room, Post-anesthesia care

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The recovery room or the post-anesthesia care unit [PACU] is a busy component of the modern surgical care system. The PACU is aimed at caring for patients recovering from anesthesia coming from adjacent operating rooms, patients anesthetized in intervention radiology, cardiology, and gastroenterology. The most common complication occurring in the PACU are respiratory events, particularly oxygen desaturation, and reintubation.

The Royal College of Anesthesiologists of Thailand supported a multicentered project namely the Perioperative and Anesthetic Adverse events in Thailand [PAAd Thai] Study in 2015, to investigate the

Correspondence to:

Charuluxananan S. Department of Anesthesiology, Faculty of Medicine, Chulalongkorn University, Rama IV Road, Pathumwan, Bangkok 10330, Thailand.
Phone: +66-2-2564215, +66-2-2564295, **Fax**: +66-2-2541931
Email: somratcu@hotmail.com

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incidences of various anesthesia and surgical related adverse events in 22 hospitals[1].

Reintubation is a serious outcome regarding respiratory complication after anesthesia. Despite criteria of extubation after anesthesia, reintubation still frequently occurs. The incidence rate of reintubation in the PAAd Thai Study was 11:10,000[2]. The present study of reintubation in the PAAd Thai Study aimed to study contributing factors and factors minimizing incident to suggests correction strategies of reintubation problems in the recovery room.

Materials and Methods

The Royal College of Anesthesiologists of Thailand supported the multicentered project of the PAAd Thai Study in 22 hospitals across Thailand. All institutions received ethical approval for the present study and informed consent was waived due to the nature of the retrospective analysis of prospective data collection. Structured data collection forms, in closed and opened-end questionnaire, were filled out by attending anesthesia personnel and/or site manager within 24 hours after an incident occurred. Details of case record forms have been described[1]. Reintubation was an interesting outcome. All incidents were collected between January 1, and December 31, 2015. Monthly statistics of main anesthetic technique was also collected and sent to the Data Management Center at Faculty of Medicine, Chulalongkorn University. Three senior anesthesiologists reviewed reintubation incidents and any discrepancy was resolved by discussion to reach a consensus. Descriptive statistics were analyzed using SPSS version 22.

Results

There were 221 incident reports occurring in the PACU with 107 reintubation cases analyzed in the present study. Twelve (11.2%) were pediatric patients under the age of 15 years. Age distribution among the case series of reintubation is demonstrated in Figure 1. Ratio of females to males was 55 (51.4%) to 52 (48.6%). Forty-one cases (38.3%) of reintubation occurred in a university-based hospital while 66 cases (61.7%) occurred in service-based hospitals. Thirteen cases (12.1%), 30 cases (28.0%), 56 cases (52.3%), and eight cases (7.5%) had a physical status 1, 2, 3, and 4 of the American Society of Anesthesiologists [ASA], respectively. Forty incidents (37.4%) occurred in emergency condition. Sixty patients (56.1%) experienced reintubation during official working hours. Eighty-three cases (77.6%) were inpatients. Operation and site of procedure are shown in Table 1. Administrative characteristics of patients are shown in Table 2.

Main anesthetic technique of all reintubation incidents were 105 cases (98.1%) of general anesthesia and two cases (1.9%) of general total intravenous anesthesia [TIVA]. Medication used is shown in Table 3. Eighty-seven cases (81.3%) and 39 cases (36.4%) were monitored by capnometer and end tidal gas monitoring, respectively. Among 107 cases, duration of anesthesia was one hour or less, one to three hours, or more than three hours in 24 cases (22.4%), 68 cases (63.6%), and 19 cases (178%), respectively. Seventy-nine cases (73.8%) received fentanyl, 57 cases (53.3%) cis-atracurium, 30 cases (28.0%) morphine, 28 cases (26.2%) atracurium, 20 cases (18.7%) midazolam, and eight cases (7.5%) rocuronium.

Anesthesia provider made the decision to re-

Table 1. Operative procedure sites of patients with reintubation

Type of surgery	Frequency (%)
General	41 (38.3)
Orthopedic	13 (12.1)
Neurological	10 (9.3)
Obstetric-gynecological	9 (8.4)
Urological	8 (7.5)
Obstetric	6 (5.6)
Thoracic	6 (5.6)
Otorhinolaryngological	5 (4.7)
Plastic	5 (4.7)
Vascular	3 (2.8)
Gynecological	3 (2.8)
Intervention	2 (1.9)
Optholmological	2 (1.9)
Cardiac	2 (1.9)
Endoscopic	1 (0.9)

Table 2. Administrative characteristics of patients

	n (%)
Type of hospitals	
University hospitals	41 (42.3)
Non-university hospitals	66 (57.9)
Emergency condition	
Emergency	41 (58.9)
Elective	63 (38.3)
ASA physical status	
I	13 (12.1)
II	30 (28.0)
III	56 (52.3)
IV	8 (7.5)

ASA = American Society of Anesthesiologists

intubate based on clinical symptoms before and after detection by monitoring equipment in 79 cases (73.8%) and 28 cases (26.2%), respectively. Seventy-five cases (70.1%) of reintubation incidents occurred with changes of monitoring indices, particularly with pulse oximetry.

Forty cases (37.4%) of reintubation incidents occurred together with occurrence of oxygen desaturation. Immediate (24 hours) and long-term outcomes (7 days) after reintubation are shown in Table 4.

After review of all incidents, 80 cases (74.8%), 71 cases (66.4%), 36 cases (33.6%), and 10 cases (9.3%) were considered as anesthetic, patient, surgical, and system factors, respectively. Fifty-six cases (52.3%), and 33 cases (30.8%) were considered as preventable and spontaneously occurring (or unavoidable) events. Sixty-two cases (57.9%) and two cases each (1.9%) were considered as knowledge-based, rule-based, and skill-based error, respectively. Contributing factors, factors minimizing incident, and suggested corrective strategies for reintubation incidents are demonstrated in Table 5.

Discussion

The present study revealed that reintubation incidence was one of most common adverse events occurring in the recovery room. Half of incidents were reintubation because of oxygen desaturation while 18.9% of incidents were reintubated and developed oxygen desaturation. Extubation failure is a high-risk event that may lead to cardiac and

Table 3. Medication anesthetics used among 107 cases of patients with reintubation

Medication/anesthetic	n (%)
Thiopental	43 (40.2)
Propofol	55 (51.4)
Midazolam	19 (17.8)
Diazepam	1 (0.9)
Succinylcholine	57 (53.3)
Pancuronium	1 (0.9)
Atracurium	28 (26.2)
Cis-atracurium	57 (53.3)
Rocuronium	8 (7.5)
Nitrous oxide	28 (26.2)
Isoflurane	4 (3.7)
Sevoflurane	48 (45.8)
Desflurane	14 (13.1)
Morphine	30 (28.0)
Pethidine	1 (0.9)
Fentanyl	79 (73.8)
Prostigmine	55 (51.4)
Atropine	55 (51.4)
Glycopyrrolate	1 (0.9)

Data were not mutually exclusive

Table 4. Immediate and long-term outcomes (7 days) of re-intubation incidents

Outcomes	n (%)
Immediate outcomes	
Unplanned ICU admission	36 (33.6)
Prolonged emergence	5 (4.7)
Major physiologic changes	
• Respiratory system (hypoxia, pulmonary edema, etc.)	40 (37.4)
• Cardiovascular system	2 (1.9)
• Neurological system	6 (5.6)
Cardiac arrest	1 (0.9)
Complete recovery	27 (25.2)
Long-term outcomes (7 days)	
Prolonged ventilator support	34 (31.8)
Prolonged hospital stay	14 (13.1)
Vegetative state	2 (1.9)
Death	1 (0.9)
Complete recovery	33 (30.8)

ICU = intensive care unit

Table 5. Contributing factors, factors minimizing outcomes, and suggested corrective strategies

Contributing factors	n (%)
Inappropriate decision making	57 (53.3)
Inadequate preanesthetic evaluation	42 (39.3)
Inexperience	25 (23.4)
Haste	12 (11.2)
Emergences	12 (11.2)
Miscommunication	10 (9.3)
Inadequate knowledge	4 (3.7)
Inadequate personnel	3 (2.8)
Factors minimizing incident	
Vigilance	74 (69.2)
Having experience	50 (46.7)
Experienced assistants	32 (29.9)
Effective communication	12 (11.2)
Compliance with guidelines	11 (10.3)
Availability of monitoring	11 (10.3)
Surgical safety checklist	6 (5.6)
Good consultation system	6 (5.6)
More monitoring equipments	4 (3.7)
Continuing maintenance of monitors	2 (1.9)
Improvement of training	2 (1.9)
Suggested corrective strategies	
Improvement of supervision	37 (34.6)
Quality assurance activity	30 (28.0)
Practice guidelines	29 (27.1)
Additional training	20 (18.7)
Improvement of communication	17 (15.9)
Surgical safety checklists	6 (5.6)
More equipment	5 (4.7)

respiratory complications, unplanned intensive care unit admission, prolonged length of hospital stay, and increased mortality. Therefore, several studies investigating incidences of extubation failure showed varied incidences of extubation failure between 2:10,000 to 35:10,000[3-6]. The Thai Anesthesia Incidents Study (THAI Study), a registry study of 163,000 cases showed an incidence of 20:10,000 in 2005[7]. The PAAd Thai incident reporting study in 2015 revealed that incidence of reintubation was reduced to 11:10,000. However, 10% of all incident reports[2] were occurring in the operating theatre and in the PACU.

Age distribution of patients with reintubation were distributed among all age groups with 45% and 10% occurred in patients over 60 and under 10 years. Therefore, careful decision making for extubation should be emphasized in both elderly and pediatric patients. This finding was similar to a previous study in Thailand[7,8]. About two-thirds of incidents occurred in emergency condition and with ASA physical status of 3 and 4. These were similar to a study of risk factors for reintubation[9]. Underlining conditions such as chronic pulmonary disease, hypoalbuminemia, and renal insufficiency were patient factors for reintubation in that case-control study[9]. The present study also demonstrated that 66% of incidents were also considered as patient factors.

Failed extubation or reintubation incidents also more frequently occurred in service-based hospitals, which was similar to our previous study in 2008[8]. A possible explanation was the higher proportion of anesthesia provided by nurse anesthetist in context of inadequate personnel in non-university hospitals. Improvement of supervision might be a factor of concern.

Common types of operation or site of procedure that demanded reintubation were similar to a previous study such as general, orthopedic, obstetric-gynecological, urological, and neurological surgeries[8,9]. Otolaryngological surgery in the present study did not pose higher risk for reintubation, which was in contrast with Rujirajindakul et al's study that airway surgery caused a 32-fold increase for development of reintubation in a university setting[9]. Our study presented average incidence among different types of surgery. Case-mixes of surgery was also different between university hospitals and service-based hospitals.

It is known that general anesthesia and mechanical ventilation can affect pulmonary function. Anesthesia can reduce functional residual capacity by half compared with preanesthetic value and causes atelectasis in more than 85% of normal adults[10]. Moreover, atelectasis, alveolar hypoventilation that may occur after administration of anesthetics related medication, in combination with ventilation-perfusion mismatch are mechanism that lead to postoperative hypoxemia or oxygen desaturation. In the present study, 81.9% used non-depolarizing muscle relaxant, 73.8% used fentanyl, 55% used reversal agents such as prostigmine and atropine, 28.0% used morphine, and 17.8% used midazolam. Medications such as pain killer, non-depolarizing muscle relaxant, and omitting of reversal of non-depolarizing muscle relaxant without neuromomuscular monitoring were considered as anesthesia related factors in the presents study. Moreover, 81.4%, 17.8%, and 58.9% of cases had anesthetic duration longer than one hour, three hours, and in emergency condition, respectively. A recent study also revealed that operative hours longer than three hours, neuromuscular blocks, and ASA physical status 3 were anesthetic factors[9].

Reintubation incidents lead to complete recovery in one-fourth and two-thirds of incidents at 24 hours and seven days, respectively, which was more likely to be anesthesia related. One-third of incidents necessitated unplanned ICU admission and prolonged ventilatory support while 13% had prolong hospital stay. There was one case of cardiac arrest that lead to death and two cases of vegetative state, which were considered as patient factors or non-anesthesia related factors. However, respiratory physiologic consequence was a crucial factor. While hypoxemia or oxygen desaturation was frequently used as a proxy of respiratory complication, timely resolution of hypoxemia outside the operating room was challenging[11]. Pulse oximetry has been used during the intraoperative period in Thailand since 2007. The use of pulse oximetry during transfer in our context, should consider the appropriateness and feasibility.

There are several limitations in the present study. Firstly, this was descriptive analysis of incident report databases regarding reintubation occurring in the PACU. Incidents also occurred in the operating theatre and in the ICU. However, there was inadequate information to study the model of anesthesia related to adverse events of reintubation. Secondly, analysis of these databases was performed retrospectively, which possibly had incomplete information. In the present study, the multicenter approach provided enough sample size to yield adequate information regarding mean characteristics of patient populations receiving

anesthesia in Thailand. Moreover, structured case record forms could have also provided the needed information. Thirdly, analysis of each adverse event might have been difficult due to different opinions of reviewers and complexity of patient, surgical, systematic, and anesthetic factors. Analysis after discussion towards a consensus among reviewers was needed. Identifying patients at risk, preexisting diseases, operative sites or types of surgery, anesthetics and opioids were accounted for in the review process.

Model of adverse events in the present study showed that human factors such as inappropriate decision making, inadequate preanesthetic evaluation, inexperience, and haste were contributing factors that might have been preventable. Vigilance, having experience, and experienced assistants also lead to suggestive strategies for improvement of supervision, compliance to guidelines, and additional training. The importance of effective communication, improvement of supervision, additional monitoring equipment to transfer patients, and using a checklist for handoffs were all systematic approaches suggested for reintubation in the PACU.

Conclusion

Reintubation or failed extubation was one of most common events in the PACU. Large proportions of incidents were considered as preventable as human factors that include inappropriate decision making, inadequate preanesthetic evaluation, inadequate vigilance were found. Crucial systematic factors were supervision system, communication, more monitoring equipment, and quality assurance activity. Suggested corrective strategies consist of improvement of supervision, compliance to guidelines, additional training, and improvement of communication.

What is already known on this topic?

Postanesthetic reintubation commonly occurred both in the operating theatre and in the PACU. The common events that lead to reintubation were upper airway obstruction, hypoventilation, and unstable hemodynamics. Most reintubation was anesthesia directly or partially related complications.

What this study adds?

Reintubation in PACU was more common in Thai non-university hospitals, pediatric, and elderly patients. Neuromuscular blocking agents, midazolam, and opioids were considered as anesthesia related factors. More than half of reintubation occurred after extubation without reversal of neuromuscular blocking agents and without neuromuscular monitoring. Half of events were considered as preventable.

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Potential conflicts of interest

The authors declare no conflict of interest.

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