A Prospective Controlled of the Rapid Sequence Intubation Technique in the Emergency Department of a University Hospital

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Objective: *To compare the time taken to intubate, the number of intubation attempts, and incidence of complications in patients undergoing rapid sequence intubation (RSI) with those intubated with non-RSI techniques in non-traumatic emergency department.*

Material and Method: *A prospective controlled study of intubation in 224 adults, half were intubated using RSI and half non-RSI. Patients' demographic details, indication for intubation, intubation technique, decision-to-tube time, open mouth-to-tube time, number of attempts, and immediate complications were recorded.*

Results: *The median open mouth-to-tube time was significantly lower in the RSI group (65 seconds [interquartile range, IQR 44 to 92 seconds] vs. 127 seconds [IQR 70 to 274 seconds], p<0.01), but there was no difference in the median decision-to-tube time (412 seconds [IQR 354 to 506 seconds] in the RSI group compared with 420 seconds [IQR 265 to 566 seconds] in the non-RSI group, p = 0.46). Intubation success rate was significantly higher in the RSI group (83.9% compared with 54.5%, p<0.01), and was superior even for less experienced intubators. The incidence of immediate complications was significantly lower in the RSI group (42.0%) than the non-RSI group (56.2%, p = 0.04).*

Conclusion: *Using RSI significantly reduced the time from laryngoscopy to confirmation of intubation, improved success rate, and reduced the incidence of complications compared with non-RSI techniques. Furthermore, the RSI technique did not prolong the time from decision-making to completion.*

Keywords: *Airway management, Intubation duration, Rapid sequence intubation*

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Endotracheal intubation is used to secure the airway in emergency situations, and emergency physicians need to be able to intubate competently, to provide effective service in the Emergency Department (ED)[1,2]. Rapid sequence intubation (RSI) is an intubation technique in which an anesthetic induction agent is administered with a rapid-onset neuromuscular blocking agent (NMBA), and is preferred in the emergency cases when patients are at risk of aspirating regurgitated gastric contents into the lungs. Rapid sequence induction renders the patient to become unconscious and paralyzed rapidly to facilitate emergent endotracheal intubation and minimize the risk of regurgitation and aspiration[3]. Several studies have reported that RSI is safer and more effective than non-RSI intubation in the ED; consequently, RSI is now considered to be the standard of care in the ED[3-5]. The technique increases success rates of intubation on the first attempt and reduces the complications of emergency airway management including hypoxia, regurgitation of gastric contents and aspiration[4-7].

In Thailand, RSI was implemented in the ED in 2007 by Emergency Medicine (EM) staff and anesthesiologists; however, we had previously shown that RSI had not been adopted into routine clinical practice. Many physicians and nurses are not confident that they have the full understanding of the drugs, equipment or the maneuvers required to perform the technique[8]. This prospective controlled study was initiated to demonstrate that adoption of RSI by qualified staff improved speed of intubation and reduced complications in the ED of a university hospital. We examined a series of non-rapid sequence endotracheal intubations followed by the same number of intubations in which the rapid sequence technique was used. The study objective was to evaluate the time from decision to confirmation of intubation, and the time from mouth opening to confirm of intubation, when using the RSI or non-RSI technique. The latter

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was our primary outcome measure, and our hypothesis was that time from mouth opening to confirmation of intubation would be shorter when RSI was used. We also measured time from decision to confirm of intubation to the time of open mouth-to-tube time, whether this might be longer when RSI was used, as the result of the additional steps needed to prepare for the RSI technique.

Material and Method

Setting and hospital system

All intubations in the non-trauma ED were performed in accordance with the Advanced Cardiac Life Support Guidelines[9]. Intubation is usually performed by the resident, chief resident or attending staff, but sixth-year medical students or externs are permitted to make the first attempt under supervision if they were present. All EM residents undertake a 1-month rotation in anesthesia to gain airway management skills before their ED placement. All residents and staff completed an accredited airway management and RSI workshop before the study began. Drugs to facilitate intubation, including induction agents, NMBAs, opioids, adjuncts and resuscitation drugs were available in the ED. All patients were monitored with an electrocardiogram, an automated blood pressure monitor, and pulse oximeter. Correct placement of the endotracheal tube (ETT) was confirmed by direct visualization, chest and epigastric auscultation, and radiography, but equipment for measuring end tidal carbon dioxide concentration was not available at the time.

Patients

Conduct of this prospective controlled study was approved by the Siriraj Institutional Review Board (SI105/2008) and registered with the Clinical Trials.gov (NCT01474252). The study was conducted in the non-trauma ED, Siriraj Hospital, Bangkok, Thailand. All patients aged 18 years or older who required airway control with endotracheal intubation were enrolled and managed with a team approach in the resuscitation room. Written informed consent was obtained from all patients' representatives if direct consent could not be obtained. Exclusion criteria included cardiac arrest, apnea, allergy to any drugs used in RSI, any contraindication to RSI including anticipated difficult airway or upper airway obstruction requiring an immediate surgical airway.

The first 112 patients were intubated using non-RSI techniques between July and October 2008. RSI was then used in the next 112 patients, who were intubated between November 2008 and February 2009. There were no restrictions on the drugs used for RSI or non-RSI techniques; intubators were allowed to determine which drugs were most appropriate for each individual patient.

RSI technique

Patients were pre-oxygenated using 100% oxygen administered via a close-fitting oxygen mask. An intravenous induction agent was administered, immediately followed by a rapid-onset NMBA[3,10]. Drugs were stored in a refrigerator in the ED. The induction agents available were thiopental, propofol, etomidate, and ketamine; the NMBAs included succinylcholine and rocuronium. Clinicians had the option to co-administer opioids, such as fentanyl, to attenuate the physiologic responses to intubation such as tachycardia and intracranial hypertension. Lidocaine was also available to blunt the rise in intracranial pressure during laryngoscopy, and atropine to prevent a reflex bradycardia from vagal stimulation during laryngoscopy.

After administration of the induction agent, manual pressure was applied to the cricoid cartilage by an assistant. After the onset of action of the NMBA, the vocal cords were visualized using a laryngoscope and a cuffed tube passed between them. After inflation of the cuff, correct positioning of the ETT in the trachea was confirmed.

Non-RSI technique

The traditional means of intubating patients in our department had been to use no drugs or minimal sedation. Patients were pre-oxygenated with 100% oxygen administered using a close-fitting oxygen mask and intubation was performed when the necessary equipment was available.

Data collection

The clinical team recorded details of each intubation on a form within 30 minutes. Completed forms were collected daily and checked by one of the authors. The authors were responsible for completing all missing data, using the ED records and information provided by the intubators.

Patients' demographic data were collected and included the presence of predictors of difficult intubation, the primary indication for intubation (the indication considered most likely to threaten the airway), the methods and process of intubation, the

drugs used to facilitate intubation (if any), decision-to-tube time (defined as the time from the EM physicians making the decision to intubate to the time of confirmation of the position of the ETT by chest auscultation), open mouth-to-tube time (defined as the time from inserting the laryngoscope into the patient's mouth to the time of confirmation of endotracheal position), status of the intubator, number of intubation attempts, hemodynamic parameters including blood pressure, heart rate and oxygen saturation before, during and after intubation, the immediate complications of intubation, and patient outcome.

The predictors of difficult intubation were assessed using the LEON evaluation (Look externally: facial trauma, large incisors, beard or moustache, large tongue; Evaluate according to the 3-3-2 rule: inter-incisor distance ≥3 fingers, hyoid-mental distance ≥3 fingers, thyroid-hyoid distance ≥2 fingers; Obstruction (e.g., hematoma, epiglottitis, large tonsils); Neck mobility limited[11].

The decision-to-tube time and open mouth-to-tube time were recorded using two stopwatches by a member of the research team. The status of the intubator was categorized as extern, first year resident, chief resident or staff. An intubation attempt was defined as placement of the laryngoscope into the patient's mouth with an intention to intubate even if an ETT was not inserted. Immediate complications were defined as those occurring at or shortly after intubation. Only complications that were detectable in the non-trauma ED were prospectively monitored and recorded.

Statistical analysis

A calculation for sample size was made based on the primary outcome of open mouth-to-tube time and was informed by the findings of our pilot study, in which the mean open mouth-to-tube time with a non-RSI technique was 300 seconds. The sample size of 112 patients per group was calculated to detect a 1-minute difference in open mouth-to-tube time between the RSI and non-RSI groups with a type I error of 0.05 and a power of 80% (nQuery Advisor version 7.0, Statistical Solutions, Cork, Ireland). Categorical variables were analyzed using the Chi-square test. Continuous variables are presented as the mean and standard deviation, or the median and interquartile range for non-normally distributed data. Comparisons between groups were made with either Student's t-test or the Mann-Whitney U test as appropriate. All statistical tests were two-tailed and $p<0.05$ was considered statistical significant. All data were analyzed using SPSS version 18 for Windows (SPSS Inc., Chicago, IL).

Results

A flow chart showing the numbers of individuals at each stage of the study was shown in Fig. 1. Seventeen patients excluded as difficult airway were predicted (LEON score greater than 2 or an immediate need for surgical airway management). Two hundred twenty four patients were included in the analysis: there were 112 patients in the RSI group and 112 patients in the non-RSI group. All patients' demographic data, LEON scores and indications for intubation were shown in Table 1.

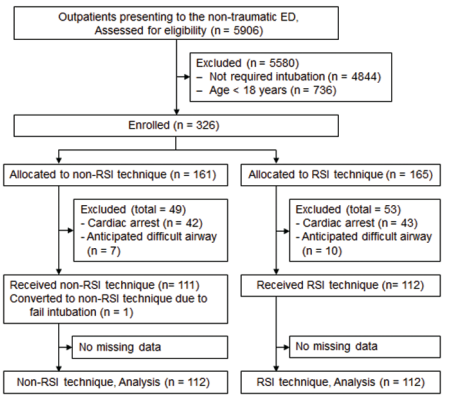

Fig. 1 Study flow diagram.

Table 1. Demographic and clinical characteristics of intubated patients, and indications for intubation

	RSI (n = 112)	Non-RSI (n = 112)	*p*-value
Sex (male:female)	65:47	69:53	0.50
Age (year)	67±15	67±16	0.78
Weight (kg)	57±9	58±10	0.26
Height (cm)	163±5	164±06	0.83
BMI (m/kg^2)	21±3	22±4	0.21
LEON score 0:1:2	82:26:4	80:27:5	0.93
Indication for intubation			
Altered mental status	1 (0.9)	5 (4.5)	0.21
Airway obstruction	2 (1.8)	3 (2.7)	1.00
Cerebrovascular accident	8 (7.1)	15 (13.4)	0.18
Heart failure	42 (37.5)	32 (28.6)	0.20
Respiratory failure	49 (43.8)	35 (31.3)	0.07
Sepsis	8 (7.1)	16 (14.3)	0.13
Shock	2 (1.8)	6 (5.4)	0.28
Seizure	1 (0.9)	5 (4.5)	0.21

RSI = rapid sequence intubation; BMI = body mass index; LEON = Look externally, Evaluate according to the 3-3-2 rule, Obstruction, Neck mobility limited (see Material and Method)
Data are presented as number (proportion expressed as a percentage) or mean ± standard deviation

In the RSI group, 92 patients (82.1%) were intubated using etomidate as the induction agent, 16 (14.3%) with propofol, three (2.7%) with ketamine, and one (0.9%) with thiopental; in the non-RSI group, two patients (1.8%) were intubated with diazepam and one (0.9%) with etomidate. In the RSI group, succinylcholine was used as the NMBA in 69 patients (61.6%) and rocuronium was used in 43 patients (38.4%). One patient (0.9%) in the non-RSI group was administered succinylcholine to facilitate intubation after multiple failed attempts.

The median open mouth-to-tube time was significantly shorter with the RSI technique (65 seconds [interquartile range, IQR 44 to 92 seconds] vs. 127 seconds [IQR 70 to 274 seconds] in the non-RSI group, $p<0.01$); however, there was no difference in the median decision-to-tube time (412 seconds [IQR 354 to 506 seconds] in the RSI group vs. 420 seconds [IQR 265 to 566 seconds] in the non-RSI group, $p = 0.46$).

The success rate on the first intubation attempt was significantly higher with the RSI technique (83.9% vs. 54.5% in the non-RSI group, $p<0.01$; Fig. 2). The rate of first attempt intubation improved with use of the RSI technique from 4 to 22% for externs, and from 25 to 31% for first year residents. The mean number of intubation attempts in the RSI group was 1.2, compared with 1.7 in the non-RSI group ($p<0.01$). There were 137 intubation attempts in the RSI group compared with 191 attempts in the non-RSI group ($p<0.01$).

Blood pressure and heart rate measured before and five minutes after intubation were broadly comparable in both groups, but mean peripheral oxygen saturation was significantly higher in those intubated using the RSI technique ($p<0.01$).

All immediate and early complications of intubation observed in the ED were presented in Table 2. Of the 110 patients (49.1%) who experienced complications, 47 (21.0%) were in the RSI group compared with 63 (28.1%) in the non-RSI group ($p = 0.04$). The most serious immediate complication was cardiac arrest in four cases (1.8%); resuscitation was successful in three patients. The 33 patients (14.7%) in whom intubation-related hypotension was observed, recovered after fluid resuscitation or administration of vasopressors. Desaturation was detected and appropriately treated in 20 patients (8.9%). Seven incidences of esophageal intubation (3.1%) and six of endobronchial intubation, bypassing the carina into a bronchus (2.7%) were detected by chest auscultation or chest radiograph. Two patients (0.8%), who aspirated regurgitated gastric contents before intubation recovered before discharge from hospital. Peri-intubation tachycardia was seen in all patients, but normal sinus rhythm was restored after correcting hypoxia and hypercarbia.

Discussion

We found that the open mouth-to-tube time was shorter in patients intubated using the RSI technique, but decision-to-tube times were not significantly different between the groups. This can be accounted for by the additional time required to prepare for RSI once the decision has been made to intubate. Importantly, we also found that the success rate on the first intubation attempt was significantly higher and the

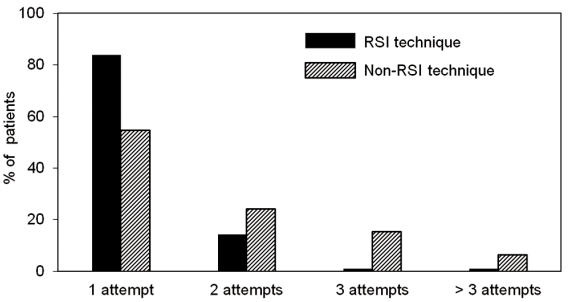

Fig. 2 The frequency of number of intubation attempts required in the rapid sequence and non-rapid sequence intubation groups.

Table 2. Immediate complications of intubation

Complication	RSI (n = 112)	Non-RSI (n = 112)	*p*-value
Airway trauma by intubator	4 (3.6)	15 (13.4)	0.01
Hypotension	20 (17.9)	13 (11.6)	0.19
Hypertension	17 (15.2)	12 (10.7)	0.32
Esophageal intubation	1 (0.9)	6 (5.4)	0.12
Mainstem bronchial intubation	3 (2.7)	3 (2.7)	1.00
Regurgitation	0 (0)	2 (1.8)	0.50
Cardiac arrest	1 (0.9)	3 (2.7)	0.62
Desaturation	5 (4.5)	17 (15.2)	0.01
Dysrhythmia	7 (6.3)	32 (28.6)	<0.01

Data are presented as number (proportion). Hypotension was defined as a post-intubation systolic blood pressure <90 mmHg or >20% lower than the pre-intubation systolic blood pressure. Hypertension was defined as a post-intubation systolic blood pressure >140 mmHg or >20% higher than the pre-intubation systolic blood pressure. Regurgitation was defined as a passive process whereby the stomach contents flow into the hypopharynx or oral cavity. Cardiac arrest was defined as an event during which a central pulse was not palpable. Desaturation was defined as oxygen saturation <90% measured by pulse oximetry. Dysrhythmia was defined as a change from the original electrocardiographic rhythm, unless changing to sinus rhythm or cardiac arrest.

total number of intubation attempts was significantly lower in the RSI group.

RSI is reportedly the most common airway management technique used by physicians to manage the airway of critically ill and emergency patients[1]. In Thailand, RSI is widespread used by anesthesiologists, but is rarely used in the ED where physicians and nurses are still not fully trained and not confident with the drugs, equipment, and physical maneuvers required[8].

Our findings are in broad agreement with other investigators, who have reported that intubation can be performed more rapidly with the RSI technique with higher success rates and fewer attempts, but without prolonging decision-to-tube time[4,6,7,12,13]. The success rate on the first attempt in our cohort of patients intubated using RSI was 83.9%, which lies within the range of 74 to 86% reported by other investigators[6,14,15]. Importantly, we also found that the first attempt intubation rate for less experienced externs rose from 4 to 22% after introduction of the RSI technique. This confirms that additional training for staff in the ED is essential.

Direct laryngoscopy and tracheal intubation are potent stimulators of the sympathetic nervous system and produce marked stress responses that increase blood pressure and heart rate[16,17]. Drugs used in the RSI technique attenuate this response, but frequently cause hypotension after intubation[18]. The hemodynamic responses that we observed after RSI were consistent with those of other investigators[8]. Etomidate is a widely used induction agent as it is reported to cause less hemodynamic instability and affords a degree of neuroprotection, and succinylcholine is the NMBA of choice because of its rapid onset and short duration. In our cohort, there were no significant differences in blood pressure or heart rate before and 5 minutes after intubation using either technique, and the incidence of post-intubation hypotension was also similar.

Although we observed significantly fewer complications in the RSI group (21% compared with 28% in the non-RSI group), our incidence is high when compared with other studies[5,6,19]. Nevertheless, there were significantly fewer incidences of tachycardia, desaturation, and airway trauma in the RSI group, likely explained by the actions of the drugs administered on the laryngeal musculature, affording improved views of the vocal cords, and facilitating passage of the ETT into the trachea. One patient in the RSI group had a cardiac arrest after intubation. Although cardiac output was restored after two minutes of cardiopulmonary resuscitation, this patient died of severe sepsis on this admission. Although three patients in the non-RSI group had post-intubation cardiac arrest, the difference in incidence between the groups was not statistically significant.

The most common intubation-related complication with the RSI technique was hypotension. Critically ill patients requiring intubation are recognized to be at increased risk of hypotension, particularly those with chronic obstructive pulmonary disease, sepsis, low body weight (less than 55 kg), or pre-intubation systolic blood pressure less than 140 mmHg[20]. These highlights the importance of taking into consideration the patient's clinical diagnosis and hemodynamic status before performing RSI. Drugs used in RSI, especially induction agents, also impair cardiovascular function. Propofol decreases systemic vascular resistance and cardiac output, while thiopental is a venodilator with negative cardiac inotropic effects: both can induce profound hypotension when administered at the normal dose used for induction of anesthesia[21]. For RSI in the ED, a reduced dose is recommended in hemodynamically compromised patients[22]. Selection of the correct dose based on body weight may also be challenging in the ED[23,24] while the dose of NMBAs such as succinylcholine and rocuronium can be calculated using total body weight, the dose of induction agents such as propofol, thiopental and etomidate should be calculated on the basis of lean body weight, especially in obese patients[24]. Therefore, it can be difficult to select the correct dose in the ED, when the weight of patients may not be known and needs to be estimated. Vasopressors and intravenous fluids should be available to address post-intubation hypotension.

The present study was a prospective study at a single institution that examined the clinical consequences of introducing RSI as the new standard of care for endotracheal intubation, in the context of routine clinical practice in a developing country where the adoption of a proven standard of care may be slow despite clear evidence and clinical need. Our study also had the advantage of documenting improvements in clinical outcomes prospectively, whereas other published studies were based on retrospective analyses[2,4-6,14,25].

Limitation

Our study had several limitations. First, we studied only patients attending the non-trauma ED, so we are unable to draw any conclusions about RSI in the trauma setting. Second, patients were not randomized: the non-RSI group all underwent

intubation before the RSI group; however, the patients' demographic and clinical characteristics and indications for intubation were broadly comparable. Third, our findings may have been influenced by self-reporting bias, measurement error, and potential confounders such as general improvement in airway management by resident physicians over time. Finally, we did not record long-term patient outcomes, so some late complications, such as aspiration pneumonia or vocal cord damage might be under-reported.

Conclusion

We found that use of the RSI intubation technique significantly decreased the time from direct laryngoscopy to intubation, improved the success rate for intubators with a wide range of previous experience and was associated with fewer complications; but did not prolong the time from decision to intubate to successful intubation when compared with non-RSI methods.

What is already known on this topic?

RSI is now considered to be the standard of care in the ED in the developed countries. In Thailand, this intubation technic had not been adopted into routine clinical practice.

What this study adds?

This prospective study demonstrates that RSI improves speed of intubation and reduces complications in the ED of a university hospital in a developing country.

Acknowledgement

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Potential conflicts of interest

None.

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การศึกษาเทคนิคการใส่ท่อช่วยหายใจ rapid sequence intubation แบบไปข้างหน้า ในแผนกฉุกเฉินของโรงพยาบาลมหาวิทยาลัย

มิ่งขวัญ วงษ์ยิ่งสิน, อุษาพรรณ สุรเบญจวงศ์

วัตถุประสงค์: *เพื่อเปรียบเทียบระยะเวลาที่ใส่ท่อช่วยหายใจ จำนวนครั้งของการใส่ และอุบัติการณ์การเกิดภาวะแทรกซ้อน ระหว่างเทคนิคการใส่ท่อช่วยหายใจ rapid sequence intubation (RSI) และการไม่ใช้เทคนิคนี้ ในห้องฉุกเฉิน*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาแบบไปข้างหน้าในผู้ป่วย 224 ราย ผู้ป่วยครึ่งหนึ่งถูกใส่ท่อช่วยหายใจโดยไม่ใช้ RSI และอีกครึ่งหนึ่งใช้ RSI ผู้นิพนธ์จะบันทึกรายละเอียดเกี่ยวกับกลุ่มประชากร ข้อบ่งชี้การใส่ท่อช่วยหายใจ เทคนิคการใส่ท่อช่วยหายใจ ระยะเวลาตั้งแต่เริ่มตัดสินใจว่าจะใส่ท่อช่วยหายใจจนใส่ท่อสำเร็จ ระยะเวลาตั้งแต่เปิดปากจนใส่ท่อช่วยหายใจสำเร็จ จำนวนครั้งการใส่ และภาวะแทรกซ้อนจากการใส่ท่อช่วยหายใจ*

ผลการศึกษา: *ระยะเวลาตั้งแต่เปิดปากจนใส่ท่อช่วยหายใจสำเร็จลดลงอย่างมีนัยสำคัญในกลุ่ม RSI 65 วินาที [IQR 44-92] เปรียบเทียบกับกลุ่มที่ไม่ใช้ RSI 127 วินาที [IQR 70-274], p<0.01ในขณะที่ระยะเวลาตั้งแต่เริ่มตัดสินใจว่าจะใส่ท่อช่วยหายใจจนใส่ท่อสำเร็จนั้นไม่มีความแตกต่างกันทางสถิติ (กลุ่มที่ใช้ RSI 412 วินาที [IQR 354-506] และกลุ่มที่ไม่ใช้ RSI 420 วินาที [IQR 265-566], p = 0.46) นอกจากนี้ในกลุ่มที่ใช้เทคนิค RSI ยังมีอัตราความสำเร็จในการใส่ท่อช่วยหายใจสูงกว่า (83.9% กับ 54.5%, p<0.01) และมีอุบัติการณ์ของภาวะแทรกซ้อนจากการใส่ท่อช่วยหายใจต่ำกว่ากลุ่มที่ไม่ใช้เทคนิค RSI (42.0% กับ 56.2%, p = 0.04)*

สรุป: *การใช้เทคนิค RSI มีผลลดระยะเวลาการใส่ท่อช่วยหายใจตั้งแต่เปิดปากจนใส่ท่อช่วยหายใจสำเร็จ เพิ่มอัตราความสำเร็จในการใส่ท่อช่วยหายใจ และการลดอุบัติการณ์ของภาวะแทรกซ้อนอย่างมีนัยสำคัญเมื่อเทียบกับการไม่ใช้ RSI นอกจากนั้นการใส่ท่อช่วยหายใจเทคนิค RSI ยังไม่มีผลเพิ่มระยะเวลาตั้งแต่เริ่มตัดสินใจใส่ท่อช่วยหายใจจนใส่ท่อช่วยหายใจสำเร็จ*