

## Part 3. Clinical Practice Guideline for Airway Management and Emergency Thoracotomy for Trauma Patients from the Korean Society of Traumatology

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The following key questions and recommendations are presented herein: when is airway intubation initiated in severe trauma? Airway intubation must be initiated in severe trauma patients with a GCS of 8 or lower (1B). Should rapid sequence intubation (RSI) be performed in trauma patients? RSI should be performed in trauma patients to secure the airway unless it is determined that securing the airway will be problematic (1B). What should be used as an induction drug for airway intubation? Ketamine or etomidate can be used as a sedative induction drug when RSI is being performed in a trauma patient (2B). If cervical spine damage is suspected, how is cervical protection achieved during airway intubation? When intubating a patient with a cervical spine injury, the extraction collar can be temporarily removed while the neck is fixed and protected manually (1C). What alternative method should be used if securing the airway fails more than three times? If three or more attempts to intubate the airway fail, other methods should be considered to secure the airway (1B). Should trauma patients maintain normal ventilation after intubation? It is recommended that trauma patients who have undergone airway intubation maintain normal ventilation rather than hyperventilation or hypoventilation (1C). When should resuscitative thoracotomy be considered for trauma patients? Resuscitative thoracotomy is recommended for trauma patients with penetrating injuries undergoing cardiac arrest or shock in the emergency room (1B).

**Keywords:** Airway management; Thoracotomy; Practice guideline; Wounds and injuries

Based on the revised recommendations, the final recommendations were confirmed after collecting opinions from trauma experts, experts from the Korean Society of Traumatology, and research method experts using the Delphi technique (Table 1).

## IN WHICH CASES SHOULD AIRWAY INTUBATION BE PERFORMED IN PATIENTS WITH SEVERE TRAUMA?

### Recommendation

Airway intubation must be initiated in severe trauma patients with a Glasgow Coma Score (GCS) of 8 or lower (1B).

### Absolute indications

- Apnea or gasping
- When hypoxia persists (SpO<sub>2</sub> <90%) in a patient with no signs of tension pneumothorax despite being given adequate oxygen
- Severe traumatic brain injury (GCS <9)

### When airway intubation must be considered

- Hemodynamic instability related to trauma (systolic blood pressure <90 mmHg)
- Respiratory failure accompanied by severe thoracic injury (breath rate >29 breaths/minutes)

### Evidence summary

The most effective method to secure oxygen supply is through airway intubation according to the European guidelines on trauma cases [1-3]. Airway intubation is indicated in patients with a GCS lower than 9 and traumatic brain injury [4]. According to the Advanced Trauma Life Support (ATLS) and Eastern Association for the Surgery of Trauma (EAST) guidelines, patients with a GCS of 8 or lower must be intubated as soon as the opportunity presents [1,5]. In patients with brain injury accompanied by multiple injuries, low blood pressure and hypoxia interact, resulting in death [6-10]. Several studies have reported that airway intubation has a positive effect in patients with traumatic brain injury [11-14]. However, not all studies produced positive results due to differences across various facilities and systems [3,15-23]. The EAST group has pointed out that no randomized controlled tri-

**Table 1.** Scores from the Delphi technique (Likert scale 1-9)

Key question	Recommendation	Mean	SD
In what cases should airway intubation be performed in patients with severe trauma?	Airway intubation must be initiated in severe trauma patients with a GCS of 8 or lower (1B).	8.4	0.9
Should RSI be performed in trauma patients?	RSI should be performed in trauma patients to secure the airway unless it is determined that securing the airway will be problematic (1B).	7.4	1.3
What should be used as an induction drug for airway intubation?	Ketamine or etomidate can be used as a sedative induction drug when RSI is being performed in a trauma patient (2B).	8.0	0.9
If cervical spine damage is suspected, how is cervical protection achieved during airway intubation?	When intubating a patient with a cervical spine injury the extraction collar can be temporarily removed while the neck is fixed and protected manually (1C).	8.0	0.8
What alternative method should be used if securing the airway fails more than three times?	If three or more attempts to intubate the airway fail, other methods should be considered to secure the airway (1B).	8.3	0.6
Should trauma patients maintain normal ventilation after intubation?	It is recommended that trauma patients who have undergone airway intubation maintain normal ventilation rather than hyperventilation or hypoventilation (1C).	8.2	0.8
When should resuscitative thoracotomy be considered for trauma patients?	Resuscitative thoracotomy is recommended for trauma patients with penetrating injuries undergoing cardiac arrest or shock in the emergency room (1B).	8.1	0.8

SD: standard deviation, GCS: Glasgow Coma Score, RSI: rapid sequence intubation, MTP: massive transfusion protocol.

als have been conducted on this question, and that there is no research on alternative methods. Although the exact scientific basis for airway intubation has not been fully established, it is implemented in real-world settings and strongly recommended in hypoxia patients [2,24]. In patients with thoracic injury showing symptoms of hypoxemia without tension pneumothorax, intubation must be performed [1,24]. In addition to the recommendations of ATLS and Prehospital Trauma Life Support, many studies have reported that intubation was performed at the prehospital stage or relatively quickly within 2 hours of hospitalization with positive results [25-30].

In a prospective multicenter observational study that compared the recovery of trauma and non-trauma patients who had been intubated, it was determined that trauma patients recovered significantly more quickly and efficiently than their non-trauma counterparts [31]. In another prospective multicenter observational study, it was shown that the most common cause of intubation was injury to the head and that rapid sequence intubation (RSI) was the most preferred method of airway management. That study also noted that the survival rate increased when nerve blockers were used [32]. Even if the criteria for intubation are not initially met, losing the chance for intubation later on can be detrimental, requiring attention and further monitoring [33]. In a 2011 meta-analysis, the safety of pre-hospital intubation was studied and significant correlations were found between pre-hospital intubation and safety outcomes [34].

## SHOULD RSI BE PERFORMED IN TRAUMA PATIENTS?

### Recommendation

RSI should be performed in trauma patients to secure the airway unless it is determined that securing the airway will be problematic (1B).

### Evidence summary

Airway intubation for severe trauma patients must be systematic. Inappropriate intubation will lead to increased morbidity and mortality rates. A prospective study compared intubation performed in emergency situation

(n=241) or non-emergency situation (n=2,136), and found that emergency patients were significantly more likely to have severe hypoxia ( $\text{SpO}_2 < 70\%$ : 25% vs. 4.4%,  $p < 0.001$ ), reflux (25% vs. 2.4%,  $p < 0.001$ ), aspiration (12.8% vs. 0.8%,  $p < 0.001$ ), bradycardia (21.3% vs. 1.5%,  $p < 0.001$ ), arrhythmia (23.4 vs 4.1%,  $p < 0.001$ ), and cardiac arrest (10.2 vs 0.7%,  $p < 0.001$ ) [35].

In trauma patients, the airway must be kept safe and RSI should be performed as soon as possible in order to minimize the possibility of aspiration. In a retrospective study that examined 1,941 emergency patients for 18 months, the number of attempts needed to succeed in airway intubation differed drastically when RSI was performed. The cumulative success rate of three attempts to intubate a hemodynamically stable patient differed significantly when no medication was used (58%, 69%, 73%), medication was used (44%, 63%, 75%), and RSI was performed (56%, 81%, 91%) [36]. In other studies it was shown that when a muscle relaxant was not used, the likelihood of intubation failing significantly increased. Accordingly, the key to successful intubation is performing RSI with the addition of appropriate medication [37].

### Acceptability and applicability

Many domestic trauma centers, emergency medical centers, and emergency rooms are already performing RSI. RSI is not difficult to apply and is deemed acceptable.

## WHAT SHOULD BE USED AS AN INDUCTION DRUG FOR AIRWAY INTUBATION?

### Recommendation

Ketamine or etomidate can be used as a sedative induction drug when RSI is being performed in a trauma patient (2B).

### Evidence summary

The side effects of etomidate must be examined carefully. In a retrospective study that examined the national trauma registry, the use of etomidate was shown to have potential adverse effects. In that study, etomidate was administered to 35 of 94 trauma patients (37%) during rapid continuous tracheal intubation. There were no

significant differences between the group that received etomidate and the group that did not receive etomidate in terms of demographic characteristics (age, 36 vs. 41 years), cause of trauma, and severity (injury severity score, 26 vs. 22). Etomidate was associated with an increased risk of acute respiratory distress syndrome and multiple organ failure after adjusting for physiological indicators, injury severity, and blood transfusion (adjusted odds ratio [OR] 3.9; 95% confidence interval [CI] 1.24-12.0). In trauma patients who were administered etomidate once, the hospitalization period was longer (19 days vs. 22 days,  $p<0.02$ ), the duration of airway intubation was longer (11 days vs. 14 days,  $p<0.04$ ), and ICU stay was also longer (13 days vs. 16 days,  $p<0.02$ ) [38].

In another prospective randomized study, etomidate and succinylcholine or fentanyl, midazolam, and succinylcholine were used for rapid continuous tracheal intubation in trauma patients at a level I trauma center [39]. In that study, adrenocorticotropic hormone tests were also performed and basal blood cortisol concentrations were recorded prior to use of sedation-inducing drugs. When all 30 patients were examined, it was concluded that there was no significant difference in patient characteristics between the etomidate group ( $n=18$ ) and the fentanyl/midazolam group ( $n=12$ ). The etomidate group had slightly higher blood cortisol levels than the fentanyl/midazolam group ( $4.2\pm 4.9$   $\mu\text{g/dL}$  vs.  $11.2\pm 6.1$   $\mu\text{g/dL}$ ,  $p<0.001$ ). In the group treated with etomidate, the duration of intensive care unit treatment was longer (8 days vs. 3 days,  $p=0.011$ ), the duration of mechanical ventilation was longer (6.3 days vs. 1.5 days,  $p=0.007$ ), and the duration of inpatient treatment was longer (14 days vs. 6 days,  $p=0.007$ ). During the study period, two trauma patients in the etomidate group died. The authors concluded that sedation-inducing drugs like etomidate should be considered in patients with severe trauma.

A retrospective study conducted in 2016 reported no significant difference in hospital mortality between etomidate and ketamine (17.3% vs. 20.4%; adjusted OR 0.80; 95% CI 0.92-2.16) in 968 patients treated with etomidate ( $n=526$ ) or ketamine ( $n=442$ ). In addition, the duration of admission to the intensive care unit and duration of mechanical ventilation were similar in each group [40]. Previous data have shown unfavorable results for the use

of etomidate in severe trauma patients, but a recent study that compared etomidate to ketamine showed contradictory results. Both ketamine and etomidate can be used in trauma patients. However, etomidate should be used carefully and adrenal function decline must be monitored.

### Acceptability and applicability

Etomidate, ketamine, and similar sedative drugs are widely used as induction drugs during intubation. The use of etomidate and ketamine during intubation is not difficult to apply and is deemed acceptable.

## IF CERVICAL SPINE DAMAGE IS SUSPECTED, HOW IS CERVICAL PROTECTION ACHIEVED DURING AIRWAY INTUBATION?

### Recommendation

When intubating a patient with a cervical spine injury, the extraction collar can be temporarily removed while the neck is fixed and protected manually (1C).

### Evidence summary

Generally, in trauma patients with multiple injuries, cervical spine fixation is performed until cervical spine fractures can be excluded through imaging. However, if the cervical spine fixation device is properly put in place, the cervical spine fixation device makes it difficult to adjust the angle of the head. This inhibits the opening of the oral cavity, which is disadvantageous for laryngoscope intubation. A prospective multicenter study confirmed that cervical spine fixation was a cause for difficulty during intubation [41]. In order to avoid difficulties in airway intubation, medical staff around the globe use manual in-line stabilization (MILS) instead of spinal fixation.

When MILS is performed, the assistant medical staff must manually fix the spine using both hands. The insertion of a laryngoscope using manual alignment stabilization has been the standard of care in emergency situations for many years. However, controversy remains regarding the manual alignment stabilization method, and negative effects have also been reported [42,43]. As an alternative

to direct laryngoscopy, fiber-optic laryngoscopy can be used by experienced medical staff as a standard testing method when the patient has stable cardiopulmonary function and spontaneous breathing [3,44].

### **Acceptability and applicability**

This technique is not difficult to apply and is thus deemed acceptable for application.

## **WHAT ALTERNATIVE METHOD SHOULD BE USED IF SECURING THE AIRWAYS FAILS MORE THAN THREE TIMES?**

### **Recommendation**

If three or more attempts to intubate the airway fail, other methods should be considered to secure the airway (1B).

### **Evidence summary**

The number of attempted airway intubations is significantly higher for trauma patients than for non-traumatic patients [45]. It was reported that 85.4% of intubations were successful in the first attempt, while 2.7% required a second attempt. For 1.5% of cases, other methods of intubation were applied after a third failure. A system for airway intubation must be implemented in order to devise a fail-safe system when intubation fails multiple times [46]. In a retrospective study of 2,833 patients, it was reported that airway-related complications increased significantly when two or more airway intubation attempts were required [47]. In a prospective multicenter study conducted over 18 months, 30% of 1,941 airway intubations required more than one attempt, and did not exceed six attempts. The cumulative success rate was 70% for the first attempt, 85% for the second attempt, and 90% for the third attempt [48]. It is essential to consider alternative methods after three attempts of airway intubation [47,49].

### **Acceptability and applicability**

The above guideline is deemed acceptable for domestic application.

## **SHOULD TRAUMA PATIENTS MAINTAIN NORMAL VENTILATION AFTER INTUBATION?**

### **Recommendation**

It is recommended that trauma patients who have undergone airway intubation maintain normal ventilation rather than hyperventilation or hypoventilation (1C).

### **Evidence summary**

Multiple studies have shown that maintaining normal ventilation is associated with a better prognosis than performing hyperventilation or hypoventilation, which is particularly evident in patients with brain injury. In addition, with the exception of patients with chest injuries, it is helpful to measure the partial pressure of carbon dioxide at the end of an expiration to maintain and monitor normal ventilation [50-53].

Recently, there has been a tendency to use permissive hypotension in hypovolemic hypotension patients, but only animal studies have been conducted on this issue [54]. In the guidelines published by Bratton et al., the treatment guidelines for brain injury patients were revised in 2017, but there were no changes in this topic [55]. The military trauma guidelines published in 2017 also recommend that hypoventilation and hyperventilation should be avoided in patients with brain injury [56].

### **Acceptability and applicability**

The above guideline is deemed acceptable for domestic application.

## **WHEN SHOULD RESUSCITATIVE THORACOTOMY BE CONSIDERED FOR TRAUMA PATIENTS?**

### **Recommendation**

Resuscitative thoracotomy is recommended for trauma patients with penetrating injuries undergoing cardiac arrest or shock in the emergency room (1B).

### **Evidence summary**

Resuscitative thoracotomy may be performed in cases



of severe shock, pericardial pressure, loss of peripheral pulse, or cardiac arrest [57-59]. However, the indications and outcomes of resuscitative thoracotomy depend on the type of injury and the presence or absence of survival signs. Survival signs are defined as the pupil reflex, spontaneous breathing, movement in response to pain stimuli, or electrical activity of the heart [57,58]. In one meta-analysis, the survival rate for patients who underwent resuscitation thoracotomy after experiencing penetrating injuries was reported to be 11.2% [57]. Jahangiri et al. [60] reported that patients with favorable vital signs had a good prognosis without neurological defects when thoracotomy was performed. Accordingly, the researchers noted that thoracotomy should be performed in patients with penetrating injuries who have favorable vital signs at the site of injury or in the emergency room.

According to a report that compared the outcomes of 959 patients with penetrating injuries who underwent resuscitation thoracotomy in the emergency room for 26 years, patients who did not exceed 15 minutes of cardiopulmonary resuscitation (CPR) or 5 minutes of cardiac arrest had a fair survival rate. The paper advised that thoracotomy should not be performed in patients without detectable vital signs [61]. However, for patients without a known time of cardiac arrest, thoracotomy should be performed depending on the situation [59]. Therefore, it is recommended that thoracotomy should be performed in patients with penetrating injuries with vital signs when cardiac arrest occurs [57,59,60].

Although it was reported that blunt trauma patients who did not exceed 10 minutes of CPR had a significant chance of being resuscitated, it was also advised that thoracotomy should not be performed on patients undergoing cardiac arrest unaccompanied by cardiac tamponade [62-65]. In addition, thoracotomy is not recommended for blunt trauma patients with multiple injuries because the survival outcomes are quite low and there is a meaningful possibility of complications involving neurological disorders or brain death [59]. In conclusion, thoracotomy should be considered depending on the situation. Thoracotomy should be performed in blunt injury patients with favorable vital signs. In blunt injury patients with cardiac arrest or no vital signs, thoracotomy is not indicated [59,66].

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is a method of resuscitation that uses a balloon to close off the aorta, reducing the amount of bleeding and temporarily redistributing the blood flow to the brain and heart. In a study that examined 76 trauma patients for 5 years, faster REBOA application increased the survival rate by stabilizing hemodynamics. In that study, 46 people (61%) survived the initial 24 hours and 35 (46%) were discharged. In order not to delay treatment, it is helpful to initiate REBOA within an average of 60 minutes from arrival and to do REBOA before cardiac arrest occurs. And to perform partial occlusion within 30 minutes in order to maintain a systolic blood pressure above 90 mmHg [67]. In another study that compared two groups (aortic cross-clamping [ACC] vs. REBOA) that were divided by propensity score matching, the latter group had a lower survival rate. However, the study was inconclusive, as higher degrees of chest injuries were observed in the ACC group, while the abdominal or intrapelvic arterial embolization ratio was higher in the REBOA group [68]. According to a multicenter prospective observational study of the aortic occlusion for resuscitation in trauma and acute care surgery registry of 114 patients (46 REBOA, 68 ACC), there was no statistically significant difference in survival rate between the ACC group (57/68; 83.8%) and the REBOA group (33/46; 71.7%) [69]. However, a simple comparison would be inappropriate due to the skewed number of cardiac arrest patients in the ACC group. In conclusion, REBOA could be used instead of ACC in hemorrhagic shock patients with severe intraperitoneal bleeding or pelvic injury [67-69].

### Acceptability and applicability

The domestic acceptance and applicability of the treatment guidelines are judged to be plausible. However, since the evidence for blunt injuries is controversial and the issue has not been well studied, the guidelines for penetrating injuries are only recommendations.

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