福岡大医紀（*Med. Bull. Fukuoka Univ.*）：33(3), 161–165, 2006

Location and Internal Pressure of Esophageal Cuffs for Alternative Airways in Humans
—Combitube vs. SUMIWAY-WB®—

Takao MASUZAKI, Eiichi GOTO and Keiichi TANAKA

Emergency and Critical Care Medicine, School of Medicine, Fukuoka University

Abstract：Alternative airways, such as the esophageal–tracheal combitube(ECT), are as important as endotracheal intubation for airway management in prehospital care. Following our experience of an esophageal rupture that occurred during cardiac massage with intubation of a Sengstaken–Blakemore tube (SBT) in a patient with cardiopulmonary arrest due to a gastric varicose vein rupture, we investigated the pressure in the esophageal cuffs of alternative airways in cases undergoing cardiac massage under similar conditions. Furthermore, we investigated the location and esophageal cuff pressure of ECT and an esophageal obturator airway, SUMIWAY-WB® (WB), which are alternative airways approved in prehospital care in Japan. [Methods] The esophageal cuffs of 3 devices, esophageal gastric tube airway (EGTA), ECT, and WB, were filled with a specified volume of air and the internal pressures were measured. ECT and WB were inserted in cases of unsuccessful resuscitation for CPA after confirmation of death. The esophageal cuff pressure was measured during cardiac massage, and the location of the cuff was confirmed by chest X-ray and CT. [Results] The mean esophageal cuff pressures were 52.4, 122, and 219.2 mmHg for ECT, EGTA, and WB, respectively, thus demonstrating that the highest pressure was obtained with WB. The cuff pressure of the ECT did not change during cardiac massage, but the pressure in the WB was affected by cardiac massage: 212 and over 280 mmHg, with and without compression, respectively. On imaging with the tube inserted, the ECT was located in the suprasternal notch, but the WB was located on the caudal side of the bifurcation of the trachea. [Conclusions] Compression injury of the esophagus and surrounding tissues may occur during the application of WB due to the high pressure of the esophageal cuff, and the fact that the cuff is located immediately below the sternal compression site. A large-scale clinical survey is needed, and modification of such tubes should be considered depending on the results.

Key words：**Combitube, Esophageal obturator airway, Alternative airways, Esophageal cuff**

Introduction

In July 2004, the application of endotracheal intubation by paramedics was approved as a specified procedure in Japan, due to the fact that prehospital first aid depends on these individuals.[1] However, the failure rate of endotracheal intubation during prehospital first aid has been reported to be up to 50% in emergency care service systems that encounter few cases that require intubation.[2)3)] The success rates of intubation with the laryngeal mask airway (LMA) and esophageal–tracheal combitube (ECT), which are alternative airways that have been approved for application by paramedics in Japan since 1991, have been reported as being

Correspondence to：Dr. Takao MASUZAKI, Department of Emergency and Critical Care Medicine, School of Medicine, Fukuoka University 7-45-1 Nanakuma, Jonan-ku, Fukuoka-City 814-0180, Japan
Tel）+81-92-801-1011 ext2928, Fax）+81-92-862-8330 e-mail）Mass0228@aol.com

higher than that of endotracheal intubation, and ventilation through these devices may be comparable to that through endotracheal intubation.[4] Furthermore, the latest guidelines, AHA G2005, have evaluated LAM and ECT as advanced airway devices that are comparable to endotracheal intubation.[5] LMA and ECT are thus considered to be as important as endotracheal intubation as methods of airway management in prehospital care. Following our experience of an esophageal rupture during cardiac massage with the intubation of a Sengstaken–Blakemore tube (SBT) in a patient with cardiopulmonary arrest due to a gastric varicose vein rupture,[6] we investigated the pressure in the esophageal cuffs of alternative airways in cases undergoing cardiac massage under similar conditions. We also paid attention to the influence of chest compression by cardiac massage using ECT and an esophageal obturator airway developed in Japan, SUMIWAY–WB® (WB),[7][8] which are alternative airways frequently used in prehospital care in Japan.

Subjects and Methods

Using these 3 types of alternative airway that have been approved for application by paramedics in Japan as of April 2006, esophageal gastric tube airway (EGTA), ECT, and WB (Fig. 1), a specified volume (20 ml for EGTA, 12 ml for ECT, 20 ml for WB) of air was infused into the esophageal cuff in order to evaluate any changes in the elasticity of the cuff material. After the cuffs were stable for 5 minutes, the internal pressure was then measured using a cuff manometer. The pressure was measured 5 times in each device, and the mean was regarded as the measured value.

Alternative airways (ECT and WB) are frequently used at emergency sites in Japan in conjunction with cardiac massage. Considering that the measurement of esophageal cuff pressure in human subjects is necessary, we inserted ECT and WB into 2 cases of an unsuccessful resuscitation for CPA after confirmation of death and obtaining consent from the family. The esophageal cuff pressure was measured during cardiac massage by connecting a blood pressure manometer to the pilot balloon of the esophageal cuff. Case 1 was a 75–year–old male, 163 cm in height and 70 kg in body weight, and Case 2 was a 67–year–old male, 170 cm in height and 70 kg in body weight. The cause of CPA was endogenous disease in each case. The

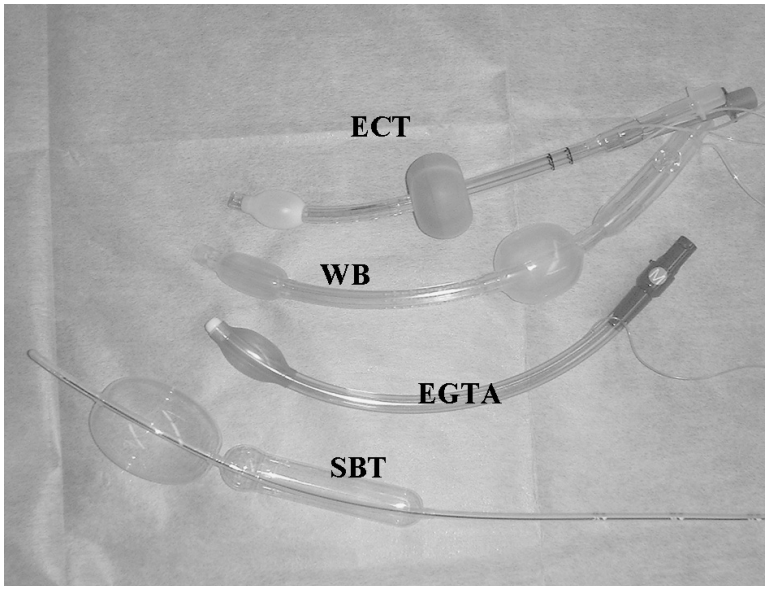


Fig. 1. Photograph of the alternative airways and Sengstaken–Blakemore tube
ECT : esophageal–tracheal combitube,
WB : SUMIWAY–WB® (esophageal obturator airway)
EGTA : esophageal gastric tube airway
SBT : Sengstaken–Blakemore tube

maximum esophageal cuff pressure was measured in the presence and absence of chest compression. The locations of the esophageal cuffs were confirmed by plain chest X-ray and CT.

Results

1) Measurement of esophageal cuff pressure

The mean of the 5 measurements of esophageal cuff pressure was 52.4, 122 and 219.2 mmHg for ECT, EGTA, and WB, respectively, thus demonstrating that the pressure exceeded the specified esophageal balloon pressure of SBT (30～40 mmHg) in all cuffs (Table 1). After death was confirmed, the ECT and WB were inserted into the body, and cardiac massage was performed, and the maximum esophageal cuff pressure was measured. The results are shown in Table 2.

In ECT, the esophageal cuff pressure in the absence of chest compression was 100 mmHg in Case 1 and 90 mmHg in Case 2, thus indicating that the pressure increased after insertion. However, the pressures in the presence of sternal compression were 102 and 94 mmHg, respectively, thus demonstrating no marked changes in the maximum esophageal cuff pressure. In contrast, for WB, the pressure in the absence of compression was 212 mmHg in Case 1 and 250 mmHg in Case 2, and it increased to greater than 280 and 300 mmHg, respectively, in the presence of chest compression, thus indicating that cardiac massage markedly increased the esophageal cuff pressure.

2) Location of the esophageal cuff

In Case 1, the ECT and WB were inserted, contrast medium was infused into the esophageal cuff, and a chest X-ray was taken to confirm the actual location of the esophageal cuff (Fig. 2). The esophageal cuff of the ECT was located in the suprasternal notch level, but that of the WB was located on the caudal side of the bifurcation of the trachea. The WB was also inserted in Case 2 after confirmation of death. Contrast medium was infused into the esophageal cuff, and posterior thoracic CT was performed (Fig. 3). The esophageal cuff of the WB was inserted on the caudal side of the bifurcation of the trachea.

Table 1. Esophageal cuff pressure

			Mean of 5 measurements
ECT	EGTA	WB	SBT
52.4 mmHg	122 mmHg	219.2 mmHg	30–40 mmHg*

*specified SBT esophageal cuff pressure

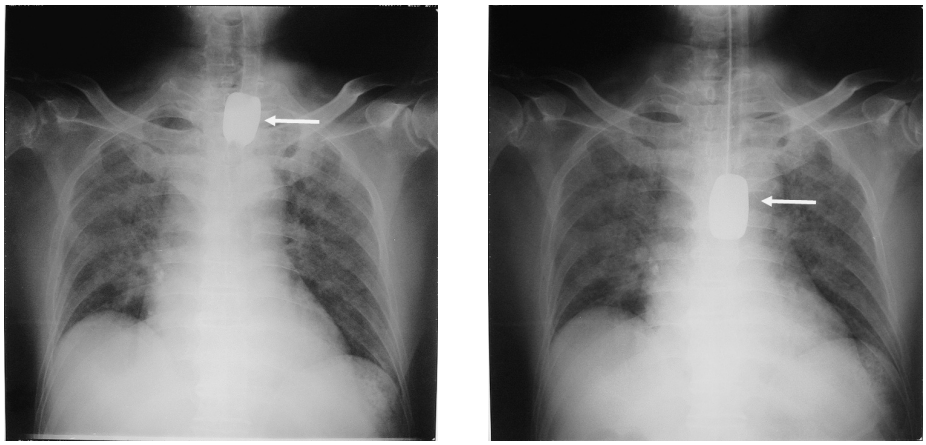
Discussion

The AHA guidelines 2000 recommended the use of the LMA and ECT as alternative airways for endotracheal intubation. However, the guidelines 2005 (G2005) classified them as advanced airway devices, similar to endotracheal intubation. G2005 provided more information on the use of LMA and ECT, and limited their use only to paramedics who had undergone sufficient training and actual practice.[5] This indicates that LMA and ECT are thus considered to be airway devices that are comparable to or more useful than endotracheal intubation, and LMA, ECT, and WB will undoubtedly remain important airway devices for prehospital care. However, complications may occur in the usage of these airway devices. The misplacement of ECT into the trachea and esophageal injury remain serious complications.[9][10] To our knowledge, there has been no report of complications with WB, which has been developed and used only in Japan,[7][8] during prehospital care.

The esophageal cuff pressure was far higher in WB than in ECT, thus demonstrating that the esophageal cuff of WB is very stiff. ECT was not affected by chest compression, but the esophageal cuff pressure in WB was markedly elevated by chest compression. When contrast medium was in-

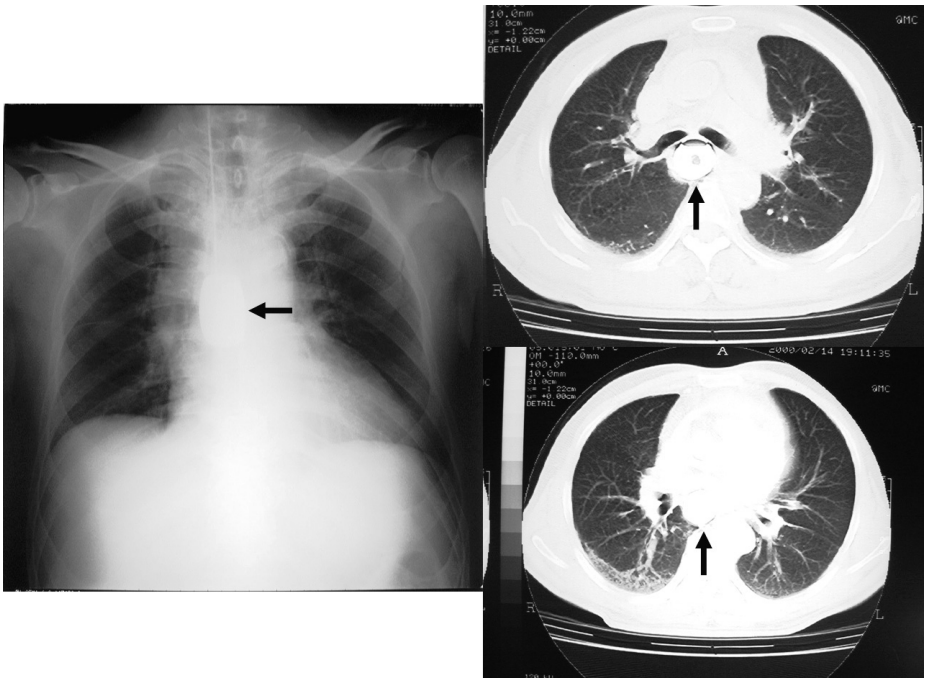
Table 2. Esophageal cuff pressure during cardiac massage

		ECT		WB	
	Case	Without compression	With compression	Without compression	With compression
No.1	75-year-old male	100 mmHg	102 mmHg	212 mmHg	over 280 mmHg
No.2	67-year-old male	90 mmHg	94 mmHg	250 mmHg	over 300 mmHg



A B

Fig. 2. A chest X-ray radiograph of case No. 1 with the intubation of the ECT and WB
A : ECT
B : WB
arrow : esophageal cuff
The esophageal cuff of the ECT was located in the suprasternal notch level, but that of the WB was located on the caudal side of the bifurcation of the trachea.



A B

Fig. 3. Chest X-ray and thoracic CT radiographs of case No. 2 with the intubation of the WB
arrow : esophageal cuff
The esophageal cuff of the WB was located just under the sternum.
A : Chest X-ray
B : Thoracic CT

fused into the esophageal cuff, and the actual location of the esophageal cuff was investigated, then the cuff of the ECT was located in the suprasternal notch level, but that of WB was located just under the sternum where the chest compression is applied during cardiopulmonary resuscitation. The location of the WB esophageal cuff was also confirmed on CT, thus revealing that it was placed immediately below the region directly compressed by cardiac massage. Based on these findings, compression injury of the esophagus and surrounding tissues may occur during the application of WB due to the high esophageal cuff pressure. Injury may also occur during the placement of such a hard cuff in the esophagus immediately below the site of the chest compressed. It is essential that the compression site during cardiac massage is accurate, and paramedics should be well trained. A large-scale clinical survey is needed, and modification of the tube may be necessary depending on the findings of such a study.

We expect that the WB, an advanced airway device unique to Japan, will be as useful as the ECT in prehospital care. However, to date, there is insufficient evidence to support the widespread use of WB. As a matter of fact, our own regional fire station does not yet employ WB. We hope that this report will lead to a large-scale clinical survey in regions where paramedics routinely use WB.

References

1) Tanigawa K, Tanaka K : Emergency medical service system in Japan; past, present, and future. Resuscitation 69 : 365-370, 2006.
2) Bradley JS, Billows GL, Olinger ML, Boha SP, Cordell WH, Nelson DR: Prehospital oral endotracheal intubation by rural basic emergency medical technicians. Ann Emerg Med 32 : 26-32, 1998.
3) Sare MR, Sakles JC, Mistler AF, Evans JL, Kramer AT, Panicioli AM: Field trial of endotracheal intubation by basic EMTs. Ann Emerg Med 31 : 228-233, 1988.
4) The American Heart Association in collaboration with the International Liaison Committee on Resuscitation (ILCOR) : Guidelines 2000 for cardiopulmonary resuscitation and emergency cardiovascular care : International consensus on science. Circulation 102 : 2000.
5) 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 112 : 2005.
6) Masuzaki T, Goto E, Tanaka K : An autopsy case of esophageal rupture caused by cardiopulmonary resuscitation with the insertion of a Sengstaken-Blakemore tube. Med Bull Fukuoka Univ 33 : 2006.
7) Watoh Y, Ishibe Y, Sato T : A new esophageal obturator airway with a pharyngeal balloon in place of a face mask. J Clin Anesth Jpn 20 : 54-58, 1996.
8) Sato N : Air way in esophagus for first first aid resuscitation. JP Patent No. 3590705, 2004.
9) Klein H, Williamson M, Sue-Ling HM : Esophageal rupture associated with the use of the Combitube. Anesth Analg. 85 : 937-939 ; 1997.
10) Stoppacher R, Teggatz JR, Jentzen JM : Esophageal and pharyngeal injuries associated with the use of the esophageal-tracheal Combitube. J Forensic Sci. 49 : 586-591, 2004.

(Received on May 8, 2006,
Accepted on June 23, 2006)