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ORIGINAL ARTICLE

Incidence of cannot intubate-cannot ventilate (CICV): results of a 3-year retrospective multicenter clinical study in a network of university hospitals

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Abstract
Purpose The purpose of this study was to investigate the incidence of cannot intubate-cannot ventilate (CICV) during general anesthesia during a 3-year period in a network of university hospitals and to evaluate the events related to it.
Methods A retrospective multicenter questionnaire survey of CICV, based on medical record review, was conducted over a 3-year period (January 2010–December 2012) in Hokkaido, Japan. All cases were assessed in terms of the suspected risk factors of CICV, the clinical course during anesthesia, and the prognosis.
Results Responses were obtained from 20 of 21 institutions (95 %) surveyed. The incidence of CICV was 3 of 97,854 cases conducted under general anesthesia (0.003 %). All incidents occurred during induction of general anesthesia. In two of the three cases, difficult airway was predicted preoperatively. In all these three cases, mask ventilation became impossible after repeated intubation attempts with devices such as the Macintosh laryngoscope, the Airwayscope, or a fiberoptic bronchoscope. A laryngeal mask was inserted in one case, but the lungs could not be adequately ventilated. Emergency tracheotomy was eventually performed in all the CICV cases. Although two of the patients did not have postoperative neurological sequelae, severe and permanent brain damage occurred in one patient.
Conclusion In our survey, we found that the incidence of CICV during a 3-year period (2010–2012) was 0.003 % or 1 in 32,000 cases. The three CICV situations occurred after repeated intubation attempts with multiple devices. The appropriate airway devices to be used in a particular difficult airway situation should be carefully considered before performing multiple attempts.

Keywords CICV · Japan · Airway device

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Introduction

Cannot intubate-cannot ventilate (CICV) situations, although rare, are major causes of death during general anesthesia [1]. The American Society of Anesthesiologists (ASA) released guidelines for difficult airway situations in 1993 [2], which were modified in 2003 [3] and 2013 [4]. After announcement of these guidelines in 1993, the odds ratio for the occurrence of severe brain damage or mortality during induction of anesthesia has reportedly decreased significantly to 0.26 (95 % confidence interval, 0.11 to 0.63) [5]. In Japan, a 2002 survey by the Japanese Society of Anesthesiologists (JSA) showed that the main cause of anesthesia-related cardiac arrest is difficulties with the airway (44 %) and ventilation (13 %), and that the incidence of severe life-threatening hypoxemia in the operating room in 2005 was lower than in 2001 (odds ratio, 0.60; 95 % confidence interval, 0.47–0.78) [6]. The JSA also released a guideline on difficult airway management [7].

In recent years, various airway devices for tracheal intubation have been introduced. The Airwayscope (AWS; Pentax, Tokyo, Japan) is the most popular device for difficult airway management in Japan. However, there is little information on the incidence of CICV in Japan after the widespread use of various airway devices and there is insufficient consensus regarding the optimal airway device

to be used in various difficult airway situations. The purpose of this study was to conduct a large-scale survey of CICV over a 3-year period in Hokkaido, Japan, to assess the possible risk factors for difficult airways, and to determine which airway devices should be selected and the order in which their use should be attempted in CICV situations.

Materials and methods

In 2012, we experienced a case of severe permanent neurological damage after CICV that occurred during induction of anesthesia. Subsequently, we decided to conduct this survey in a network of our university hospitals in Hokkaido, Japan. The protocol of this study was approved by the institutional review board of our institution (Ethical Committee No. 23-152). A retrospective, multicenter, questionnaire survey was conducted of CICV situations over a 3-year period (from January 2010 to December 2012) in 21 institutions that are a part of our university hospital network in Hokkaido, in the north of Japan. All institutions in this study were equipped with the AWS in 2009. All anesthesiologists of the hospitals in this survey belong to the same university department. The anesthesiologists of most hospitals in this survey provide anesthesia for the following specialties: Gastrointestinal Surgery, General Surgery, Cardiovascular Surgery, Thoracic Surgery, Orthopedic Surgery, Neurosurgery, Obstetrics and Gynecology, Otorhinolaryngology-Head and Neck Surgery, Urology, Dermatology, and Oral and Maxillofacial Surgery. In all these hospitals, either tracheal intubation or the laryngeal mask was used for airway management during general anesthesia, depending on the type of surgery and the position of the patient during the surgical procedure. We defined CICV as a situation in which tracheal intubation was not possible with any airway device and ventilation was impossible with a face mask and bag, despite the use of artificial oral or nasal airways, ultimately requiring emergency surgical airway access, including surgical or percutaneous tracheostomy. A questionnaire survey of the anesthetic records of each institution during the survey period was retrospectively conducted.

The questions addressed were the following:

Q1: How many cases needed airway management under general anesthesia?

Q2: How many cases of CICV were encountered during the 3-year study period (Jan 2010–Dec 2012)?

Q3: When was the CICV situation encountered?

Q4: Was the anesthesiologist in the CICV situation experienced or not?

Q5: Preoperatively, were there any risk factors of CICV in the CICV cases?

Q6: What airway devices were used to manage the CICV situation?

Q7: What was the order in which these airway devices were used?

Q8: What was the prognosis of the CICV cases?

The questionnaire was sent to the chiefs of staff of the department of anesthesiology at the 21 hospitals, who took the responsibility of being the responders for this survey, and their responses were requested within 2 months. The responders obtained data of the 3-year observation period, using the electronic database of each hospital and the specific keywords "CICV," "difficult airway," and "tracheostomy" to seek out the CICV cases. Thereafter, the responders analyzed the identified cases to assess whether they matched the definition of CICV used in this survey by examining each anesthetic record. Next, we, the authors, also assessed each anesthetic and medical record of cases definitively identified as CICV, to evaluate the preoperative factors that can predict a difficult airway, the airway devices used by the anesthesiologists for intubation, and the prognosis of the CICV cases.

Results

Responses based on the anesthesia records of each center were received from 20 institutions (95 %). The overall incidence of CICV situations was 3 of 97,895 general anesthetic cases that needed airway management, indicating an incidence of 0.003 %, i.e., approximately one event per 32,000 general anesthesia cases. All cases occurred after the induction of general anesthesia. Figure 1 shows the suspected risk factors for CICV, the course during anesthesia, management of the CICV situation, and the prognosis of each case.

Case 1: A 44-year-old man with right pneumothorax was scheduled for video-assisted thoracoscopic surgery. Preoperatively, he had no factors predictive of a difficult airway. Anesthesia was administered by an experienced anesthesiologist. General anesthesia was induced with 120 mg propofol and neuromuscular blockade was achieved by the intravenous administration of 50 mg rocuronium bromide. After induction, 5 % sevoflurane was administered and the adequacy of mask ventilation was confirmed. Visualization with a Macintosh laryngoscope revealed a Cormack–Lehane score of grade 4. After several intubation attempts under direct laryngoscopy, the AWS was used, but the trachea could not be intubated because of bleeding and secretions in the airway. Thereafter, a laryngeal mask airway (LMA) was inserted according to ASA difficult airway guidelines, but because ventilation was not adequate, the LMA was removed. Gradually, mask ventilation also became difficult, and percutaneous oxygen

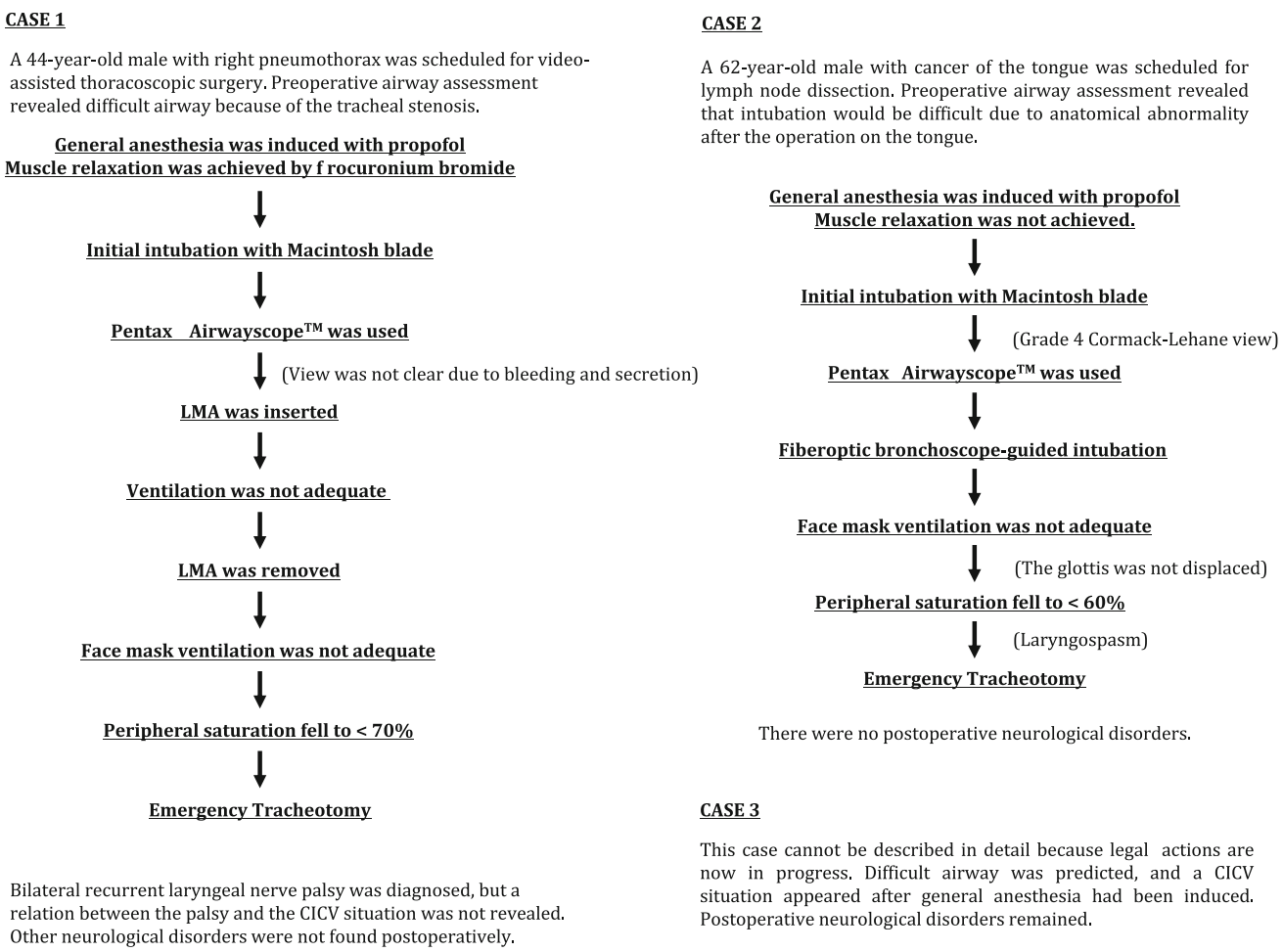

Fig. 1 Three cases of cannot intubate-cannot ventilate (CICV): predicted CICV factors, procedure during anesthesia, and prognosis

saturation (SpO_2) decreased to <70 %. Emergency surgical tracheotomy was performed by an otolaryngologist present in another operating room, and the patient's lungs were ventilated with 100 % O_2. After surgery, bilateral recurrent laryngeal nerve palsy was diagnosed, although the relationship between the palsy and CICV was not revealed. There were no other neurological sequelae.

Case 2: A 62-year old man with previously operated cancer of the tongue was scheduled for lymph node dissection. Preoperative airway assessment revealed that tracheal intubation would be difficult because of anatomical abnormalities following his previous tongue surgery. Anesthesia was administered by an experienced anesthesiologist. The anesthesiologist attempted awake intubation, but it was strongly rejected by the patient. After sufficient preoxygenation with 6 l/min O_2, general anesthesia was induced with 90 mg propofol administered intravenously without muscle relaxation. Intubation was attempted using a Macintosh laryngoscope, but it was not possible to elevate the epiglottis to see the glottis. After several intubation attempts under direct laryngoscopy, the AWS was used. However, the glottis could not be seen because of anatomical abnormalities. Fiberoptic bronchoscope-guided intubation was attempted; however, bleeding and oral secretions complicated securing the field of view. After several intubation attempts with fiberoptic bronchoscopy, the patient developed laryngospasm because of inadequate anesthesia. Thereafter, although the vocal cords were identified, tracheal intubation failed. Mask ventilation could not be performed, and SpO_2 decreased to <60 %. Emergency surgical tracheostomy was performed by the surgeon, and the patient's lungs were ventilated with 100 % O_2. Postoperatively, the patient suffered no neurological sequelae related to the incident.

Case 3: This case is not described in detail because it is currently in court. This patient was preoperatively predicted to have a difficult airway for reason of a previous history of surgery for posterior cervical fusion. The CICV situation occurred after general anesthesia with muscle relaxation was achieved. Postoperatively, the patient suffered from severe permanent brain damage because of hypoxia.

Discussion

The ASA "Closed Claims Study" demonstrated a poor prognosis following problems of the airway and ventilation [5]. The ASA published recommendations for difficult airway management in 1993 [2], which were modified in 2003 [3] and 2013 [4]; several other major guidelines are now available [8, 9]. The incidence of severe brain damage or mortality during induction of anesthesia has reportedly decreased significantly after announcement of these guidelines in 1993. This decrease is attributable to the spread of the ASA difficult airway algorithm and to advances in airway equipment, such as fiberoptic bronchoscopes and laryngeal mask airways (LMAs). The incidence of CICV in our study conducted in 21 hospitals belonging to our university hospital network in Hokkaido, Japan, was 0.003 % (one event per 32,000 general anesthesia cases), which is lower than that in a previous retrospective study of all university hospitals in Japan in 1997 (0.017 %: one event per 6,000 general anesthesia cases) [10]. The incidence of major airway management complications during general anesthesia in the UK was 46 events per million general anesthetic procedures (95 % CI, 38–54) or 1 per 22,000 (95 % CI, 1 per 26–18,000), according to the Fourth National Audit Project [9]. The difference in the incidence of CICV between the studies may be the result of the differences in the definition of CICV and the characteristics of the studies.

All CICV situations in this study occurred during induction of general anesthesia. Management of a difficult airway requires prediction and anticipation of the risk factors for a difficult airway. In our study, in two of the three CICV patients, a difficult airway was predicted preoperatively. The difficult airway guidelines published by the ASA recommend awake tracheal intubation with preservation of spontaneous breathing in patients with a preoperatively anticipated difficult airway. However, in our study, general anesthesia was induced in both the CICV cases that were preoperatively suspected to have a difficult airway despite anesthesia being conducted by experienced anesthesiologists. Ideally, the preferred approach in the two preoperatively anticipated difficult airway cases should have been preservation of the state of consciousness and spontaneous breathing, in accordance with the ASA difficult airway algorithm. In our study, the CICV situation in the two cases occurred after administration of a neuromuscular blocking agent. Recovery of spontaneous breathing is effective in improving the patient's respiratory status when CICV develops after the induction of general anesthesia [8]. In recent years, several studies have established the efficacy of sugammadex reversal of rocuronium [11, 12]. The rapid reversal of rocuronium-induced neuromuscular block by sugammadex may be potentially lifesaving in a CICV situation. However, sugammadex was not available in these CICV situations in which rocuronium was administered.

In addition, ASA and Difficult Airway Society (DAS) guidelines have recommended the insertion of supraglottic airways, such as the LMA, when mask ventilation becomes difficult (2–5). The LMA is effective in CICV situations in terms of ease of insertion and lower risk of tissue trauma compared with other airway devices. However, the LMA is not necessarily effective for the management of difficult airways. In case 1 in this study, although an LMA was inserted, ventilation was not adequate, probably for two reasons: (1) the LMA was not inserted in the appropriate position because of edema of the pharynx that resulted from tissue damage secondary to the various intubation attempts under direct visualization using the Macintosh laryngoscope; or (2) bilateral recurrent laryngeal palsy from an unknown cause. Because such a situation is not compatible with the use of an LMA, surgical airway intervention should be promptly performed in patients with bilateral recurrent laryngeal nerve palsy. In this survey, the anesthesiologists who conducted the three CICV cases were all experienced anesthesiologists who recognize the efficacy of supraglottic airways in CICV situations. In case 2, a laryngeal mask was not used because it was strongly suspected that it would not fit as a consequence of the surgically induced anatomical abnormalities.

Recently, various airway devices with video laryngoscopes, such as AWS, Glidescope (Verathon, Bothell, WA, USA), and McGRATH (Aircraft Medical, Edinburgh, Scotland, UK), have been introduced. Although many reports and randomized clinical trials have assessed the efficacy of these devices for airway management in patients with difficult airways [13–15], there is little consensus regarding the optimal equipment and the order in which the devices should be used in various difficult airway situations. It is necessary to understand the advantages and disadvantages of each airway device and choose the appropriate device according to the situation. The ASA difficult airway guidelines have contributed to decreasing mortality during induction of anesthesia, although a limitation of these guidelines is that they do not include an algorithm to determine the order in which the optimal airway devices should be chosen in any difficult airway situation. Further, unfortunately not all anesthesiologists attend the training programs and refresher courses available to them and acquire certification of competence. Hence, the anesthesia department of all hospitals should have compulsory training programs for difficult airway management.

In two of the three CICV cases in this study, tracheal intubation was unsuccessful even with use of the AWS because of poor visibility from bleeding and edema. The

flexible fiberoptic endoscope has for many years been the preferred device in difficult airway situations, and awake fiberoptic-guided intubation is a gold standard for patients with anticipated difficult tracheal intubation. However, it is difficult to perform fiberoptic-guided intubation after repeated trials with a variety of airway devices because of the resultant bleeding and tissue edema. In such patients, fiberoptic intubation with the patient in the conscious state with preservation of spontaneous breathing should be attempted at an early stage, when there is no bleeding and no airway edema.

All anesthesiologists of the hospitals in this survey belong to the same university department. We selected only these institutions because it was easy to check their electronic databases and obtain information on the CICV cases. However, because all these institutions are in Hokkaido, the results of this survey are limited to Hokkaido and not all of Japan, and are not representative of the incidence of CICV cases in all of Japan. Further, the results of hospitals that do not belong to our university hospital network were not revealed, which also explains why the total number of cases in this study was small. However, our results stress the need for several important measures to minimize the risk of CICV situations. These measures include (1) preoperative assessment for difficult airway; (2) availability of various airway management devices, such as laryngeal masks, AWS, McGRATH video laryngoscopes, and bronchoscopes, together with an understanding of the advantages and disadvantages of each of these devices; (3) preparation of a protocol for difficult airway and regular training of all anesthesiologists in the practice of this protocol using difficult airway guidelines; and (4) avoidance of repeated attempts at tracheal intubation and attempts to awaken the patient.

In conclusion, we retrospectively investigated the incidence of CICV during a 3-year period in Hokkaido, Japan. The incidence of CICV in our study was 0.003 %, indicating a decrease compared to previous studies. The awake approach is preferable in cases with an anticipated difficult airway. Further, the most appropriate difficult airway management device in a particular situation should be determined early in the airway management protocol, because multiple attempts at tracheal intubation can cause airway edema.

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