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Survey of patients whose lungs could not be ventilated and whose trachea could not be intubated in university hospitals in Japan

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Abstract
Purpose. We conducted a survey to clarify the actual circumstances in which the lungs could not be ventilated and the trachea could not be intubated (CVCI).
Methods. A questionnaire was mailed to all the university hospitals in Japan, asking about CVCI they had experienced during induction of anesthesia in 1998, and before 1997.
Results. Answers were obtained from 60 of 83 institutes. CVCI occurred in 26 of 151900 cases of general anesthesia (0.017%) in 1998. Eighteen cases occurred after induction of anesthesia by several induction methods. Five cases occurred after repeated attempts at tracheal intubation by laryngoscopy and fiberscopy in patients under awake or anesthetized conditions. In the remaining 3 cases, the situation of occurrence was not documented. Patients with CVCI had anatomical abnormalities around the upper airways, mostly from acquired diseases. CVCIs after induction of anesthesia were successfully treated by restoration of spontaneous respiration, blind intubation, laryngeal mask airway, and transtracheal approaches, and CVCIs after repeated attempts at intubation were treated mostly by transtracheal approaches. No serious consequences occurred in any patients in 1998. Twenty cases were reported before 1997, and 2 were specific, in which CVCI followed malplacement of a tracheal tube, and serious consequences, death and brain damage, respectively, followed. In other patients, no serious consequences occurred, although cardiac arrest occurred in 1 patient.
Conclusion. This survey demonstrates that CVCI can occur in any situation in which the airway is not established. Furthermore, effective treatments may be different depending on the situation, and delayed recognition of tracheal tube misplacement may lead to a serious outcome.

Key words Difficult airway · Difficult intubation · Difficult ventilation · CVCI · Questionnaire

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Introduction

Management of a difficult airway is an important issue for anesthesiologists [1–3]. In particular, the situation in which the lungs cannot be ventilated and the trachea cannot be intubated (CVCI) is the most challenging for anesthesiologists, because urgent and appropriate treatments are mandatory to prevent brain damage or cardiac arrest arising from rapidly developing hypoxia [1–3]. Several reports have described successfully treated cases of CVCI [4–10] or made general comments on CVCI [2,3]. However, because there have been no comprehensive studies of CVCI, we conducted a large-scale survey of CVCI cases in university hospitals in Japan.

Subjects, materials, and methods

A questionnaire was mailed to the departments of anesthesia of all 83 university hospitals in Japan on April 1, 1999, asking for a reply within 2 months. No university hospital had a children's hospital. CVCI and the total number of cases of general anesthesia during the year 1998 were asked about. The incidence of CVCI was calculated from the data for the year 1998 because it was assumed that the reliability of the data from 1 year immediately before the questionnaire would be high. However, CVCI data for only 1 year might be insufficient to know the whole extent of CVCI, because CVCI is very rare. So CVCI at any period before 1997 was also asked about to supplement the 1998 data. CVCI is defined as the situation in which both ventilation with a facemask and bag, despite the use of oral or nasal artificial airways and tracheal intubation with direct laryngoscopy, as is usually done, is difficult, and life-threatening events cannot be avoided without additional airway interventions. In this questionnaire, we asked the anesthesiologists to document freely the

course of anesthesia and its outcome in cases of CVCI during the induction of anesthesia. We chose the university hospitals because data are usually well managed in these institutes.

Results

There were responses from 60 (72.3%) of the 83 institutes. We analyzed the reported cases and excluded those cases that were apparently not CVCI, and asked about the cases that were dubious as CVCI by telephone or fax.

Twenty-six of 73 cases reported as CVCI in 1998 were determined to be CVCI by our analysis. Three of the other 47 cases were CVCI after extubation. Fourteen of these 47 cases were determined to be difficult intubation without difficult ventilation. The remaining 30 cases were excluded because there was no response to our confirmatory questions.

Twenty of 76 cases reported as CVCI before 1997 were determined to be CVCI. Four of the other 56 cases were CVCI after extubation. Twenty-two of the 56 cases were determined to be difficult intubation without difficult ventilation. The remaining 30 cases were excluded because of no documents having been left in 10 and no responses to confirmatory questions in 20.

The cases with no response to our confirmatory questions in 1998 and before 1997 were from the same two institutes. These cases, if they were CVCI, would greatly influence the result of this study. However, the incidence of CVCI in 1998 reported in these two institutes was high (0.51% and 0.15% respectively) compared with the other institutes (median, 0; range, 0–0.11%), so it was concluded that many of these cases from these two institutes were not CVCI, or that these two institutes were different from the others in regard to the reporting of CVCI. Therefore the data for these two institutes were excluded from the statistical analysis.

CVCI in 1998

The situations of occurrence of CVCI were classified into two groups. CVCI occurred after administration of anesthetics and/or muscle relaxant (after induction of anesthesia) in 18 cases. In 5 other cases, ventilation was maintained at first and CVCI followed after repeated attempts at tracheal intubation. In the remaining 3 cases, the situation of occurrence was not documented.

The incidence of CVCI during the induction of anesthesia was 0.017% (26/151 900).

CVCI after induction of anesthesia (Table 1)

The induction methods were described in 9 of 18 cases. CVCI followed administration of intravenous anesthetics and muscle relaxant in 6 cases (nondepolarizing muscle relaxant in 5; succinylcholine in 1) nondepolarizing muscle relaxant with inhalation anesthetics in 1, inhalation anesthetics in 1, and sedative only in 1 case. The larynx had been recognized in one patient by direct laryngoscopy with the patient under sedation just before the induction of anesthesia.

Causative diseases or abnormalities in the face and/or neck were described in 13 cases; non-malignant disease in 6 (acromegaly, 1; scar from burn, 1; obstructive sleep apnea, 2; obstructive sleep apnea and ossification of posterior longitudinal ligament, 1; abscess in the neck, 1), malignant disease only in 5 (the mouth, 1; tongue, 1; thyroid, 1; larynx, 1; epipharynx, 1), tonsillar hypertrophy and carcinoma of the neck in 1, and congenital disease (Treacher Collins syndrome) in 1 case. Two of the 6 patients with malignant disease had a history of operation on the face and neck.

Successful treatment was described in 16 cases; the translaryngeal approach was used in 8 (blind intubation, 4; laryngeal mask airway [LMA], 3; fiberscopic intubation, 1), the transtracheal approach was used in 3 (tracheostomy, 2; cricothyrotomy, 1), and restoration of spontaneous respiration in 5. Induction methods were reported in 4 cases of restoration of spontaneous respiration; induction without muscle relaxant in 1 and induction with muscle relaxant in 3 (vecuronium, 2; succinylcholine, 1). Four failed attempts were described in 3 cases; the translaryngeal approach in 3 (fiberscopic intubation, 2; Bullard (Cicron, ACMI, Stamford, CT, USA) rigid laryngoscope, 1), and cricothyrotomy with the Mini-Trach II (Concord/Portex, Kenne, NH, USA) in 1 case. In 1 failed case of cricothyrotomy with the Mini-Trach II, anatomical abnormality of the neck prevented the proper placement of the tube. The outcome was described in 14 patients, and no sequelae were reported in any of these patients.

CVCI after repeated attempts at tracheal intubation (Table 2)

The attempted methods of intubation were described in all cases; direct laryngoscopy under general anesthesia was used in three patients, and fiberscopy in two (under sedation and topical anesthesia). Bleeding of the upper airway was recognized in one patient.

Causative diseases or abnormalities making intubation difficult were described in all cases; malignant disease in four (larynx, 2; tongue, 1; neck, 1) and non-malignant disease in one (rheumatoid arthritis). One patient had a history of radiation therapy for neck carcinoma.

Successful treatment was described in five cases; the transtracheal approach was used in four (tracheostomy, 3; cricothyrotomy, 1) and the translaryngeal approach, in one (LMA). Three failed attempts were described in

Table 1. Eighteen cases of CVCI after induction of anesthesia in 1998

Age (years)/Sex	Method of induction	Causes of CVCI	Successful treatment	Failed attempt	Sequelae	Comments
NA	N_2O, O_2, sevoflurane, vecuronium	Mouth ca.	Tracheostomy	NA	No	Sa_{O_2} 40% with pulse oximeter during CVCI
NA	NA	NA	Blind intubation	NA	NA	Child
NA	NA	NA	Blind intubation	NA	NA	
NA	Thiamylal, vecuronium	Acromegaly	Blind intubation	Fiberoptic intubation, cricothyrotomy (Mini-Trach II)	No	
NA	NA	Neck ca., tonsillar hypertrophy	Blind intubation	NA	No	Child
NA	Only sedative	Tongue ca.	Cricothyrotomy	NA	No	
19/Female	N_2O, O_2, sevoflurane	Treacher Collins syndrome	Emergence from anesthesia	NA	No	
63/Female	Thiamylal, scc	Thyroid ca.	Emergence from anesthesia	NA	No	History of operation on the neck
NA	NA	NA	Fiberoptic intubation	NA	No	
NA	NA	NA	LMA and then fiberoptic intubation through it	NA	No	
NA	NA	Contracture of face, neck from burn	LMA and then fiberoptic intubation through it	NA	No	
NA	NA	Laryngeal ca.	Emergence from anesthesia	NA	No	
NA	NA	NA	NA	NA	NA	
NA	NA	Obstructive sleep apnea	NA	NA	NA	
59/M	Thiopental, vecuronium	Neck absess	Spontaneous respiration and then tracheostomy	Intubaton with Bullard laryngoscope	No	Larynx had been recognized just before induction with laryngoscopy under sedation
NA	Thiopental, vecuronium	Obstructive sleep apnea	LMA and then emergence from anesthesia	NA	No	
66/M	Midazolam, vecuronium	Epipharyngeal ca.	Tracheostomy	No	No	History of operation on the epipharynx and neck
NA	Propofol, vecuronium	Obstructive sleep apnea, OPLL	Spontaneous respiration and then fiberoptic intubation	Fiberoptic intubation	No	

CVCI, lungs cannot be ventilated and trachea cannot be intubated; NA, no data available; LMA, laryngeal mask airway; OPLL, ossification of posterior longitudinal ligament; ca., cancer; scc, succinylcholine

Table 2. Five cases of CVCI after repeated attempts at tracheal intubation in 1998

Age/Sex	Condition during attempt at intubation	Attempted method of intubation	Causes of difficult intubation	Events during attempt at intubation	Successful treatment	Failed attempt	Sequelae	Comments
81/Female	Fentanyl, propofol	Fiberoptic intubation	Laryngeal ca.	NA	Tracheostomy	NA	No	
NA	General anesthesia	Direct laryngoscopy	Neck ca.	NA	LMA and then fiberoptic intubation through it	NA	No	History of radiation therapy on the neck
NA	General anesthesia	Direct laryngoscopy	Rheumatoid arthritis	NA	Tracheostomy	Fiberoptic intubation, Trachlight	No	
NA	General anesthesia	Direct laryngoscopy	Laryngeal ca.	NA	Cricothyrotomy and then tracheostomy	NA	No	
49/Male	Droperidol, fentanyl	Fiberoptic intubation	Tongue ca.	Bleeding of upper airway	Tracheostomy	Cricothyrotomy (two 14-G needles)	No	Bradycardia, VPC during the situation of CVCI

NA, no data available; LMA, laryngeal mask airway; VPC, ventricular premature contractions

two cases; fiberscopic intubation in one, light-guided intubation with the Trachlight (Laerdal Medical, Long Beach, CA, USA) in one, and cricothyrotomy with two 14 G needles in one. The outcome was described in five patients and no sequelae were reported in any of these patients.

Unknown circumstances of the occurrence of CVCI (Table 3)

The circumstances of occurrence of CVCI were not documented in three cases. Acromegaly was reported as the causative disease in one patient. These cases were successfully treated, by tracheostomy in two, and emergence from anesthesia in one. Two failed attempts were reported in one patient; intubation with a fiberscope and intubation with a Bullard rigid fiberscope.

CVCI before 1997

The situations of occurrence of CVCI in cases before 1997 were classified into three groups; CVCI after induction of anesthesia, in ten; after repeated attempts at tracheal intubation, in eight; and after malplacement of the tracheal tube, in two.

CVCI after induction of anesthesia (Table 4)

The induction methods of anesthesia were described in five of the ten cases; after administration of intravenous anesthetics and muscle relaxant in three patients (nondepolarizing muscle relaxant, 2; not described, 1) and after inhalation anesthetics in two. No airway difficulties had been experienced in the operation 1 month before in one patient with metastatic cancer in the cervical spine.

Causative diseases or abnormalities in the face and/or neck were described in eight cases; non-malignant disease in five (gigantism, 1; scar from burn, 1; cervical spine disease, 1; tonsillar hypertropy, 1; burn in the airway, 1), malignant disease in two (cervical spine 1; the mandible, 1), and congenital disease in one (1st and 2nd brachial arch syndrome). One of the two patients with malignant disease had a history of operation on the face and neck.

Successful treatment was described in all ten patients; the translaryngeal approach was used in three (blind intubation, 1; other, 2), the transtracheal approach was used in six (tracheostomy), and emergence from anesthesia in one. In two cases of the translaryngeal approach classified as "other", patent airway and ventilation were maintained by an endotracheal tube inserted through a nostril with the mouth and other nostril occluded, and fiberoptic intubation was performed through an endotracheal tube which was inserted from the other nostril. Three failed attempts were described in three patients; translaryngeal ap-

Table 3. Three cases of CVCI of unknown circumstances of occurrence in 1998

Age/Sex	Causes of CVCI	Successful treatment	Failed attempt	Sequelae
NA	Acromegaly	Tracheostomy	NA	No
NA	NA	Tracheostomy	NA	NA
NA	NA	Emergence from anesthesia	Fiberoptic intubation, Bullard rigid fiberscope	NA

NA, no data available

proach in three (retrograde intubation 2; LMA, 1). The outcome was described in nine patients and no sequelae were reported in any of these patients, although cardiac arrest occurred in one.

CVCI after repeated attempts at tracheal intubation (Table 5)

The attempted methods of intubation were described in all eight cases; direct laryngoscopy under general anesthesia was used in five, fiberscopy in two (under sedation and topical anesthesia, 1; not described, 1) and through an LMA under general anesthesia in one. Bleeding of the upper airway was recognized in five patients, edema of the larynx or upper airway was seen in two, and cough reflex and laryngospasm were seen in one patient during the intubation attempt.

Causative diseases or abnormalities leading to difficult intubation were described in three patients; malignant disease in two (pharynx, 1; oral base, 1) and nonmalignant disease in one (micrognathia).

Successful treatment was described in seven patients; the transtracheal approach was used in five (tracheostomy in, 3; percutaneous transtracheal jet ventilation, 1; cricothyrotomy, 1), the translaryngeal approach was used in one (blind intubation), and restoration of spontaneous respiration in one. One failed attempt was described in one patient; fiberscopic intubation had been employed. The outcome was described in seven patients and no sequelae were reported in any of these patients.

CVCI after malplacement of the tracheal tube (Table 6)

CVCI after malplacement of the tracheal tube was reported in two patients. In one patient, an attempt at tracheal intubation was performed with fiberscopy under topical anesthesia for an anticipated difficult airway arising from anatomical abnormalities due to malignant tumor and a previous operation on the neck. CVCI occurred after the administration of intravenous anesthetics and muscle relaxant, which were administered at a time when the anesthesiologist misjudged that the trachea was intubated. In the other patient, CVCI occurred after the anesthesiologist misjudged that the trachea was intubated by a retrograde approach after several attempts at laryngoscopy in a patient suffering from rheumatoid arthritis in whom difficult intubation was recognized after the induction of anesthesia. Emergency tracheostomy was tried in both patients. In the former patient, tracheostomy could not be performed because of anatomical abnormalities in the neck, resulting in death. In the latter patient, tracheostomy was performed; however, brain damage followed.

Discussion

The high response rate, 72.3%, obtained in this questionnaire shows that these results reflect the actual circumstances of CVCI in university hospitals in Japan. The incidence of CVCI during the induction of anesthesia was 0.017% (1.7/10000). A previous retrospective study, calculated from reports of airway failures resulting in brain damage or death, estimated the incidence of CVCI to be 0.01–2/10000 [2]. A prospective study reported a greater incidence, 10/10000 [6]. The large difference in the incidence of CVCI among studies could result from differences in the definition of CVCI, differences in the characteristics of the patients involved, differences in strategies for difficult airways, and differences in the designs of studies.

CVCI during induction of anesthesia resulted from the coexistence of failed intubation and failed ventilation, due to obstruction of the airway by the administration of anesthetics and/or muscle relaxant, or by repeated attempts at tracheal intubation. The risk factors for difficult intubation have been well studied and recognized [2,3,11], although not all difficult intubations can be predicted by any present means [3,11]. The frequency of failed intubation was reported to be 0.13% to 0.28% [3]. On the other hand, there have been few studies of the risk factors for difficult mask ventilation [12], and estimation of the risk factors for failed ventilation is difficult due to its very low incidence (0.01%–0.06%) [3,12]. Therefore, the prediction of CVCI is inevitably difficult. The prevalence of patients with acquired anatomical abnormalities in the face and/or neck in the present study may reflect the high risk of CVCI in these patients, or the relatively large number of these patients.

One case before 1997 showed that a history of no difficult airway does not necessarily imply no difficult airway in such patients as those with malignant disease

Table 4. Ten cases of CVCI after induction of anesthesia before 1997

Age (years)/Sex	Method of induction	Causes of CVCI	Successful treatment	Failed attempt	Sequelae	Comments
60/Male	Propofol, vecuronium	Metastasis to cervical spine	Tracheostomy	Retrograde intubation	No	General anesthesia without airway difficulty 1 month before
NA	Thiopental, vecuronium	Gigantism	Blind intubation	NA	No	
NA	NA	NA	Tracheostomy	NA	No	Cardiac arrest
NA	NA	Mandibular ca.	Tracheostomy	Retrograde intubation	No	History of operation on the face and neck
50/Male	i.v. Anesthetic, muscle relaxant	Contracture of face, neck from burn	Tracheostomy	LMA	No	
NA	NA	NA	Emergence from Anesthesia	NA	NA	
NA	NA	Cervical spine disease	Other[a]	NA	No	
60/Male	NA	Tonsillar hypertrophy	Tracheostomy	NA	No	
37/Male	N_2O, O_2, sevoflurane	Burn in the airway	Tracheostomy	No	No	
4/Female	N_2O, O_2, sevoflurane	1st and 2nd Brachial arch syndrome	Other[a]	No	No	

NA, no data available; LMA, laryngeal mask airway

[a] In these two patients, airway and ventilation were maintained by an endotracheal tube inserted through a nostril with the mouth and other nostril occluded, and fiberoptic intubation was performed through an endotracheal tube inserted from the other nostril

Table 5. Eight cases of CVCI after repeated attempts at tracheal intubation before 1997

Age (years)/Sex	Condition during attempt at intubation	Attempted method of intubation	Causes of difficult intubation	Events during attempt at intubation	Successful treatment	Failed attempt	Sequelae comments
NA	N_2O, O_2, isoflurane, vecuronium	Direct laryngoscopy	NA	Laryngeal edema	Spontaneous respiration and then fiberoptic intubation	NA	No
NA	General anesthesia	Intubation through LMA	Pharyngeal ca.	Bleeding of upper airway	PTJV and then tracheostomy	NA	No
NA	General anesthesia	Direct laryngoscopy	NA	Bleeding of upper airway	Tracheostomy	NA	No
NA	General anesthesia	Direct laryngoscopy	NA	Bleeding of upper airway	Tracheostomy	NA	No
NA	General anesthesia	Direct laryngoscopy	NA	Bleeding of upper airway	Blind intubation	NA	No
NA	General anesthesia	Direct laryngoscopy	NA	Edema of upper airway	Tracheostomy	Fiberoptic intubation	No
50/Male	Neuroleptic analgesia	Fiberoptic intubation	Micrognathia	Cough, laryngospasm	Cricothyrotomy (Mini-Trach II), and then tracheostomy	NA	No
NA	NA	Fiberoptic intubation	Oral base ca.	Bleeding of upper upper airway	NA	NA	NA

NA, no data available; LMA, laryngeal mask airway; PTJV, percutaneous transtracheal jet ventilation

Table 6. Two cases of CVCI after malplacement of the tracheal tube before 1997

Age (years)/Sex	Methods of induction	Cause of difficult airway	Course and sequelae
NA	Only sedative	Malignant tumor and a previous operation on the neck	An attempt at tracheal intubation was performed with fiberscopy under topical anesthesia for an anticipated difficult airway. CVCI occurred after the administration of intravenous anesthetics and muscle relaxant that were administered at a time when the anesthesiologist misjudged that the trachea was intubated. Emergency tracheostomy was tried, but failed because of anatomical abnormalities in the neck, resulting in death.
67/Female	N_2O, O_2, enflurane, pancuronium	Rheumatoid arthritis	CVCI occurred after the anesthesiologist misjudged that the trachea was intubated by a retrograde approach after several attempts at laryngoscopy and fiberscopy. Emergency tracheostomy was performed; however, brain damage followed.

NA, no data available

around the upper airway. In another such case, in 1998, we reconfirmed that a good laryngoscopic view with the patient under sedation does not always mean a good view under general anesthesia [13].

Considering the incompleteness of criteria for the predictability of difficult airways [1,3,11,12], it is safer to prepare for CVCI in all cases of anticipated difficult intubation. It is important to determine how to obtain a definite airway for anticipated difficult airways. Awake intubation is usually recommended, and is useful because loss of airway patency by anesthetics will be avoided [1,2]. It is controversial as to how the induction of general anesthesia should be performed in patients with a risk of CVCI [1,14]. The present study showed that there were no induction methods that had no risk of CVCI, although induction with inhalation anesthetics without the use of muscle relaxant is usually chosen because emergence from anesthesia is possible [14].

Our study reemphasizes the importance of trying tracheal intubation gently and nontraumatically, avoiding thoughtless repeated attempts with any method of intubation and any consciousness level [1–3], and observing the tube in the trachea by the measurement of expired CO_2 waveform or by fiberscopy in patients with difficult airways [1–3].

An airway must be established in cases of CVCI without delay to prevent serious consequences. Airways were established by restoration of spontaneous respiration in several patients after the induction of anesthesia both in 1998 and before 1997, and in one patient before 1997 after repeated attempts at tracheal intubation. Restoration of spontaneous respiration is one choice for CVCI [1,2]. However, it is difficult to restore respiration before life-threatening hypoxia occurs if complete airway closure occurs just after a muscle relaxant has been administered [15], so this method is not indicated for all cases of CVCI.

An LMA established an airway in several patients after the induction of anesthesia and in one patient after repeated attempts at intubation in 1998, and, before 1997, LMA failed in one patient after induction of anesthesia. An LMA can establish an airway above the glottis. The obstruction after induction of anesthesia is usually above the glottis. So, LMA is effective in these cases [4,16], although proper placement may be difficult in patients with anatomical abnormality in the upper airway. An LMA is recommended for CVCI from the aspects of efficacy, ease of performance, and lesser risk of trauma compared with the other methods [4–6,16]. However, the LMA was not used so often in the present study, presumably due to the apparent difficulty of insertion in the local pathologies in the upper airway. Success in securing an airway by LMA after repeated attempts at intubation [5,6] shows that the cause of CVCI in these patients was at least partially in the supraglottis, and LMA is worth trying in these patients.

Blind intubation was effective in several patients after the induction of anesthesia in 1998, and in a few patients after the induction of anesthesia and after repeated attempts at intubation before 1997. Tracheal intubation may be successfully performed by a blind attempt; however, it must not be performed repeatedly and without forethought because it may worsen the situation [1–3,6]. CVCI was successfully treated by ventilation through an endotracheal tube placed near the larynx through the nostril in two patients before 1997. The usefulness of this method was reported for difficult intubation [17], but not for CVCI. Further investigations are necessary to confirm the usefulness of this method.

The few successful cases, despite several attempts with fiberoptic intubation both in 1998 and before 1997, show that fiberoptic intubation is not suitable for CVCI. Recognition of the larynx by fiberscopy within a short time is difficult in anesthetized patients and needs skill, especially in those patients with difficult airways [1–3,14]. The success of retrograde intubation for CVCI was reported in another study [6], although only failed

cases before 1997 were reported in the present study. The failure of several other translaryngeal approaches designed for difficult intubation showed the ineffectiveness of these methods for CVCI.

Transtracheal approaches successfully established an airway in many cases of CVCI, both after the induction of anesthesia and after repeated attempts at tracheal intubation, both in 1998 and before 1997. Tracheostomy was most often used successfully, and cricothyrotomy, utilizing the Seldinger technique, was less often used successfully, both in 1998 and before 1997, while transtracheal jet ventilation was successful in one patient before 1997. Percutaneous transtracheal jet ventilation and cricothyrotomy, utilizing the Seldinger technique, are recommended because they can be performed rapidly and easily by anesthesiologists [18,19]. However, these methods were not used so often, presumably because they were not in widespread use, and a surgeon able to perform a tracheostomy could arrive promptly. Transtracheal approaches must be prepared for every patient with a risk of CVCI, because they are reliable for every kind of CVCI. However, anatomical abnormalities around the neck may lead to a failure of transtracheal approaches, as shown in this study.

The American Society of Anesthesiologists (ASA) algorithm for difficult airways shows that, in cases of CVCI, one more intubation attempt or emergency nonsurgical airway ventilation (transtracheal jet ventilation, LMA, or Combitube (Sheridan Catheter, Argyle, NY, USA)) is tried first, and an emergency surgical airway is recommended if these approaches fail [1]. The adequacy of the ASA algorithm was confirmed by the present study, although the Combitube was not used despite the lesser risk of aspiration than with the LMA [2,3], presumably because of its rare use in anesthesia [20]. Furthermore, our study suggests that effective treatments are different depending on the situation; i.e., translaryngeal and transtracheal approach for CVCI after the induction of anesthesia, and a transtracheal approach for CVCI after repeated attempts at intubation. Our study also shows that preparation for each alternative method is important, because there are no guaranteed methods, although the acquisition and improvement of skills for each method is necessary.

Serious consequences were reported in two patients before 1997 following delayed recognition of malplacement of the tracheal tube. This suggested that CVCI after misplacement of the tracheal tube is liable to cause serious consequences, presumably because the appropriate treatments will be delayed. There has been no statistical analysis of the outcome of CVCI, although CVCI would be a major cause of serious complications following adverse respiratory events [21]. Our findings showing no sequelae in 1998 shows that CVCI was managed in university hospitals in Japan. Preparation for difficult airways and CVCI will certainly enhance success and minimize risk.

The data collected in our study may be incomplete because the sources of data from each institute may not always have been from records, and data regarding each item were not always sufficient because the replies to questions were not always specific. However, this study clearly showed the actual circumstances of CVCI. The data in this study were collected from institutes with different methods of induction of anesthesia and different strategies for difficult airways, so comparisons of the risks or safety of CVCI among the various methods of induction of anesthesia and establishment of an airway, and comparisons of the effectiveness of each treatment, were difficult.

In summary, this survey demonstrated that CVCI can occur after the induction of anesthesia with any induction method, after repeated attempts at tracheal intubation with any intubation method, and after malplacement of a tracheal tube in patients with anatomical abnormalities in the face and/or neck. Furthermore, effective treatments may be different depending on the situations of occurrence, and misplacement of a tracheal tube may lead to a serious outcome. Further studies are necessary to establish a method for the prediction of a difficult airway and to determine the optimum methods for the prevention and treatment of CVCI.

References

1. Caplan RA, Benumof JL, Berry FA, Blitt CD, Bode RH, Cheney FW, Connis RT, Guidry OR, Ovassapian A (1993) Practice guidelines for management of the difficult airway. A report by ASA Task Force on Management of the Difficult Airway. Anesthesiology 78:597–602
2. Benumof JL (1991) Management of the difficult adult airway. With special emphasis on awake tracheal intubation. Anesthesiology 75:1087–1110
3. Crosby ET, Cooper RM, Douglas MJ, Doyle DJ, Hung OR, Labrecque P, Muir H, Murphy MF, Preston RP, Rose DK, Roy L (1998) The anticipated difficult airway with recommendations for management. Can J Anaesth 45:757–776
4. Baraka A (1993) Laryngeal mask airway in the cannot-intubate, cannot-ventilate situation. Anesthesiology 79:1151–1152
5. Nagahama H, Suzuki Y, Takeda T, Aoki T, Takahashi K, Shimoyama T (1995) The use of a laryngeal mask in a newborn infant with Nager acrofacial dysostosis. Masui (Jpn J Anesthesiol) 44:1555–1558
6. Parmet JL, Colonna-Romano P, Horrow JC, Miller F, Gonzales J, Rosenberg H (1998) The laryngeal mask airway reliably provides rescue ventilation in cases of unanticipated difficult tracheal intubation along with difficult mask ventilation. Anesth Analg 87:661–665
7. Omote K, Kawamata T, Imaizumi H, Namiki A (1999) Case of Cowden's disease that caused airway obstruction during induction of anesthesia. Anesthesiology 91:1537–1540
8. Terayama S, Komatsu K, Nishiyama T, Hanaoka K (2000) Airway obstruction after general anesthesia in a patient with the first and second brachial arch syndrome. Masui (Jpn J Anesthesiol) 49:1271–1273

9. Szokol JW, Wenig BL, Murphy GS, Drezek E (2001) Life-threatening upper airway obstruction after tongue base surgery. Anesthesiology 94:532–534
10. Esclamado RM, Glenn MG, McCulloch TM, Cummings C (1989) Perioperative complications and risk factors in the surgical treatment of obstructive sleep apnea syndrome. Laryngoscope 99:1125–1129
11. El-Ganzouri AR, McCarthy RJ, Tuman KJ, Tanck EN, Ivankovich AD (1996) Preoperative airway assessment: predictive value of a multivariate risk index. Anesth Analg 82:1197–1204
12. Langeron O, Masso E, Huraux C, Guggiari M, Bianchi A, Coriat P, Riou B (2000) Prediction of difficult mask ventilation. Anesthesiology 92:1229–1236
13. Sivarajan M, Fink BR (1990) The position and the state of the larynx during general anesthesia and muscle paralysis. Anesthesiology 72:439–442
14. Mason RA (1999) The obstructed airway in head and neck surgery. Anesthesia 54:625–628
15. Benumof JL, Dagg R, Benumof R (1997) Critical oxyhemoglobin desaturation will occur before return to an unparalyzed state from 1 mg/kg intravenous succinylcholine. Anesthesiology 87:979–982
16. Benumof JL (1996) Laryngeal mask airway and the ASA difficult airway algorithm. Anesthesiology 84:686–699
17. Arai T, Tabo T, Takaishi K, Nagaro T, Kimura S (1989) Nasotracheal intubation using fiberoptic bronchoscopy in infants and children. J Anesth 3:103–104
18. Benumof JL, Schiller MS (1989) The importance of transtracheal jet ventilation in the management of the difficult airway. Anesthesiology 71:769–778
19. Bainton CR (1994) Cricothyrotomy. New concepts in airway management. Int Anesthesiol Clin 32:95–108
20. Gaitini LA, Vaida SJ, Mostafa S, Yanovski B, Croitoru M, Capdevila MD, Sabo E, Ben-David B, Benumof JL (2001) The Combitube in elective surgery. Anesthesiology 94:79–82
21. Caplan RA, Posner KL, Ward RJ, Cheney FW (1990) Adverse respiratory events in anesthesia: a closed claims analysis. Anesthesiology 72:828–833