Need for Emergency Surgical Airway Reduced by a Comprehensive Difficult Airway Program

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BACKGROUND: Inability to intubate and ventilate patients with respiratory failure is associated with significant morbidity and mortality. A patient is considered to have a difficult airway if an anesthesiologist or other health care provider experienced in airway management is unable to ventilate the patient's lungs using bag-mask ventilation and/or is unable to intubate the trachea using direct laryngoscopy.

METHODS: We performed a retrospective review of a departmental database to determine whether a comprehensive program to manage difficult airways was associated with a reduced need to secure the airway surgically via cricothyrotomy or tracheostomy. The annual number of unplanned, emergency surgical airway procedures for inability to intubate and ventilate reported for the 4 yr before the program (January 1992 through December 1995) was compared with the annual number reported for the 11 yr after the program was initiated (January 1996 through December 2006).

RESULTS: The number of emergency surgical airways decreased from 6.5 ± 0.5 per year for 4 yr before program initiation to 2.2 ± 0.89 per year for the 11-yr period after program initiation ($P < 0.0001$). During the 4-yr period from January 1992 through December 1995, 26 surgical airways were reported, whereas only 24 surgical airways were performed in the subsequent 11-yr period (January 1996 through December 2006).

CONCLUSIONS: A comprehensive difficult airway program was associated with a reduction in the number of emergency surgical airway procedures performed for the inability of an anesthesiologist to intubate and ventilate, a reduction that was sustained over an 11-yr period. This decrease occurred despite an increase in the number of patients reported to have a difficult airway and an overall increase in the total number of patients receiving anesthesia per year.

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Inability to intubate and ventilate patients with respiratory failure is associated with significant morbidity and mortality. A patient is considered to have a difficult airway if an anesthesiologist or other health care provider experienced in airway management is unable to ventilate the patient's lungs using bag-mask ventilation and/or is unable to intubate the trachea using direct laryngoscopy. Treatment algorithms for difficult airway management developed by the American Society of Anesthesiologists (ASA) presume the availability of equipment and expertise in a "cannot intubate, cannot ventilate" situation.[1]

The literature is replete with publications that describe the use of various types of advanced airway equipment,[2–4] surveys of the availability of such devices,[5–10] and use of simulators to teach difficult airway management skills,[11] as well as articles that identify the need to educate residents in advanced airway techniques.[12–15] However, very little is written on the organization of resources and staff to manage the difficult airway. In 2000, Showan and Sestito[16] proposed that the components of a successful airway management system include personnel, training, an emergency response system, an oversight process, standardized equipment, and patient education. Just as with any type of emergency, preparedness is the key when planning for response.

A comprehensive airway program was introduced at our institution in 1996. Up until that time, investigation of cases that required a surgical airway for inability of an anesthesiologist to intubate and ventilate revealed three contributing factors: 1) the inability to access the written medical record, resulting in a lack of preoperative information about the patient's airway, 2) the lack of immediate access to equipment and

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In memory of Marvin Witcher.

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Table 1. Difficult Airway Program Timeline

Date instituted	Component of difficult airway program
1996	Standardized airway cart
1996	Education of support staff to manage airway cart supplies and equipment
1996	Difficult airway information added to electronic patient record
1997	Formalized airway education program
1997	Preanesthesia assessment form with standardized airway examination
2000	Simulated airway training
2001	Continuous updating of current airway technology
2006	Support staff availability 24 h/d, 7 d/wk

supplies necessary to manage a difficult airway, and 3) the lack of availability of trained personnel to help manage and secure the airway. The comprehensive airway program incorporated electronically communicated patient information that could be accessed at any time; education of health care providers on a regular basis with simulated teaching of technical skills; immediately accessible advanced airway equipment with support staff to manage it; and skilled staff from the departments of anesthesiology and surgery available around the clock with the goal of improving the care of patients with difficult airways and prevention of adverse airway events. We hypothesized that this program would be associated with a reduced need for emergency surgical airway procedures (cricothyrotomy or tracheostomy) in difficult airway situations.

METHODS

The core components of the comprehensive difficult airway program were divided into communication, equipment, personnel, and education. The program was initiated in 1996 and developed over time as some components were added and others expanded (Table 1). We obtained IRB approval to review records of patients who were reported to have a difficult airway or who required an emergency surgical airway procedure (cricothyrotomy or tracheostomy).

Communication

Communication of information about a patient's difficult airway can greatly impact the anesthesiologist's airway management plan. Before 1996, a departmental difficult airway database was implemented and linked to the operating room (OR) scheduling program. Despite the lack of a standard definition of difficult airway, commonly understood criteria for a difficult airway included failed mask ventilation, failed intubation, Grade 4 view at laryngoscopy, and the need for multiple laryngoscopies. When a difficult airway was encountered, the patient's information was detailed in the patient's written chart and entered into the departmental difficult airway database. Patients with both expected and unexpected difficult airways were entered. Although the OR schedule offered an alert for patients with a difficult airway, written medical records containing previous anesthesia documentation were not reliably available in a timely fashion, and data records were often incomplete. For this reason, other avenues of communication were developed to disseminate this information.

In 1996, an Anesthesia Consultant Report was developed to electronically disseminate critical patient information to clinical staff.[17] A more specific Difficult Airway Note became available electronically in 2000 that provided details of a patient's airway management when a difficult airway was encountered, including the anatomic issues and the technique(s) used to manage the airway. Both the Anesthesia Consultant Report and the Difficult Airway Note were incorporated into the hospital's electronic patient record (EPR), a web-based program housed on a secure, password-protected, fire-walled server accessible to clinical staff 24 h a day, 7 days a week. In 2002, an "Alert" area was added to the EPR that immediately notified the health care provider of specific problems when the record was accessed. In addition to the difficult airway alert, other EPR alerts included malignant hyperthermia and the isolation status of the patient.

Beginning in 1996, inpatients who were known to have a difficult airway had a green alert band attached next to their patient identification band. This alert band stayed with the patient throughout the hospitalization. Before discharge, the patient or, when appropriate, family members or health care agents were provided information about the airway management. After discharge, a letter was sent to the patient's home with details of the airway anatomy and the techniques used to secure the airway. The patient was told to bring this letter to the anesthesiologist and surgeon for future surgery. A MedicAlert® brochure was also sent to the patient should they would want to purchase a MedicAlert® bracelet or be enrolled in the MedicAlert® program. Patients with known difficult airways presenting for outpatient or same-day admit surgery also received a difficult airway alert band in the preoperative area before entering the OR.

The Anesthesia Preoperative Evaluation form was redesigned in 1997 to include documentation of an objective airway examination distinct from the traditional, unstructured head, eyes, ears, nose, throat found on most physical examination forms. This documentation used checkboxes and measurements as detailed in Figure 1. A checkbox was also added in the history section to indicate a possible difficult airway based on examination or history (Fig. 2). When a patient's airway was assessed as possibly difficult to manage, an alert was placed on the OR schedule, the OR coordinator was notified so that the anesthesia personnel assignment was appropriate, and arrangements were made to ensure that equipment was available in the OR before case start. A patient was

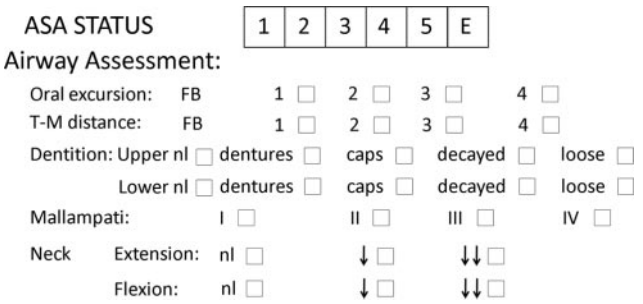

Figure 1. Preoperative airway assessment documentation. FB = finger breadths; nl = normal.

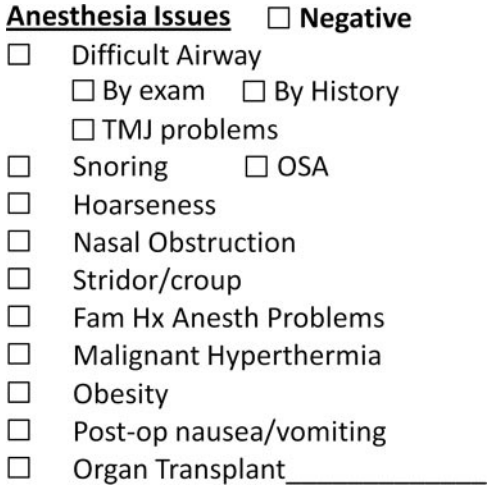

Figure 2. Preoperative anesthesia issues documentation. TMJ = temporomandibular joint.

entered into the difficult airway database based on identification or confirmation of a difficult airway in the OR during airway management.

Equipment

A mobile difficult airway cart was designed to hold all of the equipment and supplies that an anesthesiologist would need for advanced airway management, including a flexible fiberoptic bronchoscope, light source, laryngeal mask airways (LMA) (LMA North America, San Diego, CA), airway exchange catheters, and cricothyrotomy kit. In most areas, at least one cart was also equipped with a camera and video monitor. A list of the contents of the cart is detailed in Table 2. Before creation of this cart, airway equipment was stored in various locations in the OR (i.e., flexible bronchoscopes in one room, disposable supplies in another workroom) and extra time and personnel were needed to gather all of the equipment and transport it to a particular location. The difficult airway cart was transported by an equipment or critical care technician who was responsible for cleaning and restocking the equipment and supplies after each use. Over time, several identically organized mobile carts were made available for the OR suites as well as for the obstetrical suite and intensive care units. In addition, a laminated card with the ASA Difficult Airway Algorithm was attached to each cart. This standardization of equipment and supplies together in one cart was considered essential to the success of the program.

Because medications such as lidocaine and phenylephrine were kept in the difficult airway carts, regulatory agencies required that these carts be secure.[18] Tamper-evident locks were placed on the carts after they were stocked, and the carts were stored in secure areas that were either locked or under constant supervision. A key requirement in the design of the system was the ability to clean and prepare a cart for reentry into service. This constraint was addressed by using premade sealed inserts with defined equipment that could be replaced much faster, more consistently, and more dependably than by restocking items individually. The rate-limiting step became cleaning the flexible bronchoscope after its use.

At the start of the program, the intubation and ventilation techniques used after failed laryngoscopy were flexible bronchoscopy, light wand stylet (Trachlight, Laerdal Medical, Toronto, Canada), and LMA (Table 3). When the Aintree Intubating Catheter (Cook Medical, Bloomington, IN) became available at our institution for fiberoptic-assisted intubation through the LMA, this technique became more frequently used after failed laryngoscopy. The number of available flexible bronchoscopes increased with the introduction of the difficult airway carts.

Personnel

An interdisciplinary team was organized in 1996 to assist in airway management when problems arose with endotracheal intubation or bag-valve-mask ventilation. This team included an anesthesiologist, a surgeon from the Department of Otolaryngology, Head and Neck Surgery, and an equipment technician, who would bring a cart containing the necessary airway equipment. A request for airway assistance was initiated by the anesthesiologist or by a member of the medical team caring for the patient.

For the program to be successful in a large institution with more than 60 anesthetizing locations, nine intensive care units, and 1000 beds, an educated, dependable support staff was essential. Anesthesia technical staff (critical care and equipment technicians) were trained to be able to set up, clean, stock, and maintain the equipment and supplies around the clock.

Education

Before initiation of the difficult airway program, education was sporadic, consisting of occasional resident conferences and individual teaching by attending anesthesia staff. After implementation of the program, a formal education program for the anesthesiology staff was instituted. In-service classes on the use of the equipment and supplies were scheduled. Airway classes and workshops were held within the department at the beginning of each academic year and were repeated

Table 2. Contents of the Anesthesia Difficult Airway Cart

Drawer 1	No.	Drawer 2	Par
Clamp, Rochester	1	Endotracheal tubes (sizes 6.0, 7.0, 8.0, 9.0)	3
Magill forceps	1		
Magill forceps, small	1	Emesis basin	1
Yankauer suction	2	Suction catheter, 14F	3
Intravenous catheters (18, 16, 14 gauge)	1	Endotracheal tube stylets (pediatric and adult sizes)	4
Cotton-tipped applicators	1	Light wand stylets (infant, child, and adult sizes)	3
Tongue blades	10		
Steriglide™	10	Light wand handle	1
10-mL syringes	1	Nasopharyngeal airways (sizes 6.5 F, 7.0 F, 7.5 F, 8.0 F)	5
16-Gauge needles	4		
Alcohol swabs	5	Short laryngoscope handle	1
Lidocaine labels	1	Miller #4 laryngoscope blade	1
Phenylephrine labels	10		
Bivona swivel connector	1		
Mucosal atomization device	1		
Anti-fog solution	1		
Biopsy valve	1		
Suction valve	1		
Lidocaine HCl, 4%	1		
Lidocaine HCl, 0.5%	3 vials		
Phenylephrine, 1%	1 vial		
Glycopyrrolate, 0.02%	2 vials		
Lidocaine HCl, topical 2%	2 vials		
Difficult airway ID bracelets	1 bottle		
Lidocaine, 2% jelly	3–4 tubes		
Lidocaine, 2%	3 vials		

Drawer 3	Par	Drawer 4	Par
Baby-safe ventilating bag	1	LMA (sizes #1, #1.5, #2, #2.5, #3, #4, #5)	7
Oxygen face mask, adult	1		
Oxygen tubing	1		
Nasal cannula	1		
Airway, Ovassapain	1		
Airway, Williams	1		
O_2 Face mask, pediatric	1		
Adult nebulizer	1		
Drawer 5		**Top and side of cart**	
Intubating LMA	1	Light source	1
Cricothyrotomy kit (includes scalpel, Kelly clamp, and size 5.0-mm uncuffed endotracheal tube)	1	4.7-mm flexible fiberoptic scope	1
Spare battery	1	Aintree intubation catheter	1
		Airway exchange catheter (8F, 11F)	2

LMA = laryngeal mask airway.

Table 3. Chronology of Airway Device Availability

Year	Airway device
Before 1996	Fiberoptic bronchoscope
	Light wand (Trachlight)
	Classic laryngeal mask airway
	Eschman intubation stylet
1998	Aintree intubation catheter
1999	Bullard scope
2000	Upsherscope
2001	Intubating laryngeal mask airway
2008	Glidescope

periodically throughout the year with hands-on workshops and mannequin models to provide practice opportunity with advanced airway management devices and patient-based learning discussions of difficult airway scenarios. Anesthesiology residents were offered an airway rotation with a didactic focus on the management of the difficult airway coupled with a "hands-on" simulation component that allowed the trainee to use a variety of difficult airway devices on an airway mannequin. An interdisciplinary Grand Rounds dedicated to issues related to airway management was presented twice per year. The ASA Difficult Airway Algorithm was posted on the difficult airway carts for use as a visual cue.[1]

Data Collection and Analysis

After obtaining IRB approval, we reviewed our departmental difficult airway database retrospectively for cases from January 1992 to 2006 to determine the annual frequency of difficult airways reported and the number of unplanned emergency surgical airway procedures performed because an anesthesiologist was

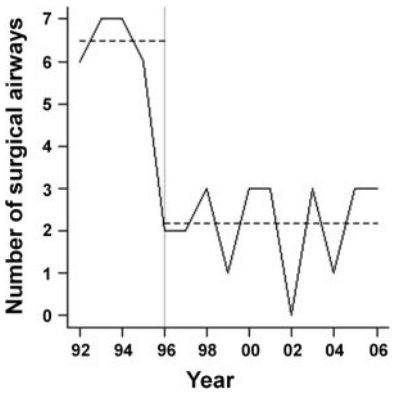

Figure 3. Annual number of emergency surgical airway procedures performed to secure a difficult airway. The difficult airway program was implemented in 1996.

unable to intubate or ventilate. We did not include emergency cricothyrotomy performed by trauma surgeons in the Emergency Department. The annual number of unplanned emergency surgical airway procedures for inability to intubate and ventilate reported for the 4 yr before the program (January 1992 through December 1995) was compared with the annual number reported for the 11 yr after the program was initiated (January 1996 through December 2006).

The method for reporting a difficult airway to the database changed during the data collection period. Before 2000, physicians used a call-in line with an answering machine to report patients deemed to have a difficult airway. In 2000, one of the physicians (LB) began to carry a pager (available for messages 24 h/d, 7 d/wk) for the reporting of difficult airways to accumulate data for a study supported by MCIC Vermont Inc. examining best practices for management of the difficult airway; the call-in line remained an option. In 2004, a web-based reporting system was instituted, replacing the pager and call-in line notification. This change to a web-based reporting system may have been temporally related to the decrease in the number of reported cases.

Data are presented as mean ± SD. Comparison between the two groups was performed with Student's *t*-test and Fisher's exact tests. A linear regression model was used to allow for an autoregressive correlation structure to assess whether a change in the reporting system in 2004 resulted in a significant change in the number of difficult airways reported. Generalized least squares were used to estimate the relative change in the mean number of surgical airways between the pre- and postintervention periods. A Spearman rank correlation coefficient was calculated to demonstrate the linear association between the number of awake intubations and the number of reported difficult airways.

RESULTS

The annual frequency of emergency surgical airways decreased from 6.5 ± 0.5 before initiation of the comprehensive difficult airway program to 2.2 ± 0.89 after the program was initiated ($P < 0.0001$). The estimated relative change in the mean number of surgical airways between the pre- and postintervention periods is 0.29 (95% confidence interval: 0.29–0.44, $P < 0.001$). During the 4-yr period from January 1992 to December 1995, 26 surgical airways were reported, whereas only 24 surgical airways were performed in the subsequent 11-yr period (January 1996 through December 2006). These results are depicted in Figure 3. The variability in reported emergency surgical airways after initiation of the program does not appear to be related to provider, level of experience, or equipment availability.

Table 4 lists the details of the emergency surgical airway events reported during the study period, including patient demographics, location, and timing of events. There were no statistically significant differences in patient age, gender, history of difficult airway, or location of surgical airway events between the pre- and postprogram periods. Most emergency surgical airways were required during induction of anesthesia both pre- and postprogram, with a shift toward emergence/postextubation in the postprogram time period; however, there were no statistically significant differences in timing when pre- and postprogram events were compared. The postextubation surgical airway events that occurred in the postprogram time period are described in Table 5. The number of deaths related to airway management was small during both periods; four deaths were reported during the period before 1996, and two deaths were reported during the period 1996–2006. The rate of death was lower after 1996, but the difference between the two periods was not statistically significant because of the small numbers (0.038 vs 0.007, $P = 0.16$).

Figure 4 shows the number of patients reported to have a difficult airway from 1992 to 2006. After 2000, the number of reports increased in association with the institution of a difficult airway pager for reporting. Overall, the number of difficult airway reports increased by 15.5 reports per year up until 2005 (95% confidence interval: 0.7–30.3), at which point the rate of reporting significantly decreased ($P = 0.042$). The average risk of emergency surgical airway in OR patients preprogram was 2.5 per 10,000 cases, whereas in postprogram, the average risk was 0.5 per 10,000 case ($P = 0.022$). The total number of patients undergoing anesthesia increased steadily over both time periods from 27,188 in 1992 to 41,884 in 2006.

The number of reported awake intubations per year according to the database increased slightly after initiation of the program. During the reporting period 1992–1995, an average of 14 awake intubations were performed per year, compared to an average of 16.6 reported per year from 1996 to 2006. The correlation between the number of awake intubations and the

Table 4. Patient Demographics, Timing, and Location of Emergency Surgical Airway Events

Parameter	Preprogram[a]	Postprogram[b]	*P*
N	26	24	
Age (yr) ± SD	51 ± 12	52 ± 14	0.787
% Male (*N*)	65 (17)	67 (16)	>0.99
% Known difficult airway (*N*)	46 (12)	63 (15)	0.272
% Occurrence in operating room (*N*)	77 (20)	67 (16)	0.533
% Occurrence during induction (*N*)	69 (18)	46 (11)	0.151
% Occurrence intraoperatively	4 (1)	4 (1)	>0.99
% Occurrence at emergence or within 2 h of extubation	8 (2)	29 (7)	0.069
% Occurrence during code or intubation call	19 (5)	21 (5)	>0.99

[a] January 1992 through December 1995.

[b] January 1996 through December 2006.

Table 5. Description of Surgical Airway Events Postextubation in the Postprogram Time Period

Year	Surgery	History of difficult intubation	Timing of event	Details of event	Adverse outcome related to event
1999	Colectomy	No	Emergence	Difficulty breathing after extubation, intubation attempts failed, surgical airway	None
2000	Thoraco-abdominal aneurysm repair	No	Emergence	Airway lost during exchange of double lumen tube at end of case, unable to intubate, LMA placed before surgical airway	None
2000	Laparoscopic cholecystectomy	Yes	Emergence	Failed extubation, unable to reintubate, LMA placed before surgical airway	None
2003	Kidney transplant	No	Emergence	Airway obstruction after extubation, unable to intubate or ventilate, surgical airway	Bleeding encountered during surgical airway, cardiac arrest, patient stabilized. Expired POD #3 due to hepatic failure
2003	Biliary stent	No	PACU	Patient hypoxic in PACU, unable to ventilate or intubate, surgical airway	Cardiac arrest during surgical airway, patient stabilized. Expired 2 wk later due to chronic hepatic failure
2005	Cervical fusion	Yes	PACU	Respiratory distress in PACU, transferred to ICU, failed intubation, LMA placed before surgical airway	None
2006	Cervical incision and drainage	No	PACU	Seizure in PACU, intubation attempts failed, LMA placed before surgical airway	None

LMA = laryngeal mask airway; PACU = postanesthesia care unit; ICU = intensive care unit; POD = postoperative day.

number of reported difficult airways was estimated to be 0.50 ($P = 0.054$).

DISCUSSION

The comprehensive difficult airway program that we describe here was associated with a reduction in the number of emergency surgical airway procedures performed for the inability of an anesthesiologist to intubate and ventilate, a reduction that was sustained over an 11-yr period. This decrease occurred despite an increase in the number of patients reported to have a difficult airway and an overall increase in the total number of patients receiving anesthesia per year. After initiation of the difficult airway program, the number of emergency surgical airways reported annually varied from 0 to 3, which may have been due, at least in part, to patient factors. Airway-related deaths also declined after the initiation of the difficult airway program, although the difference was not statistically significant because of low numbers.

There is limited literature on the incidence of emergency surgical airways after failed intubation. Two

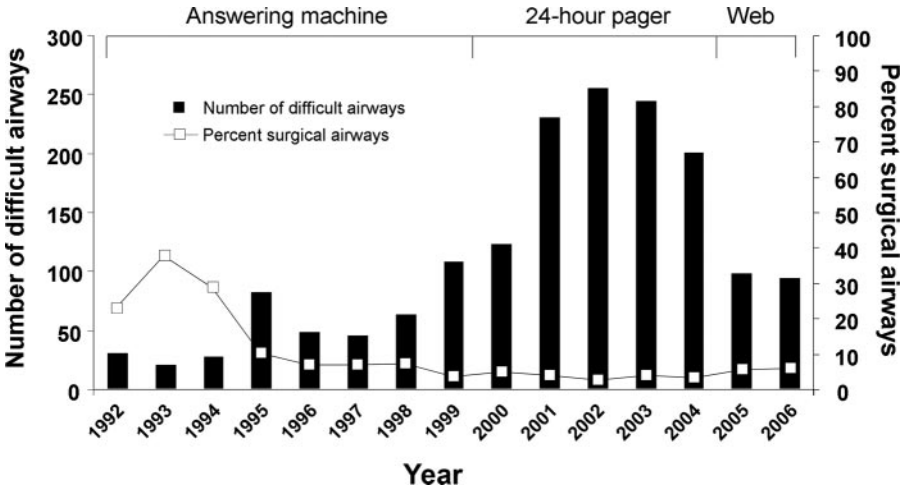

Figure 4. Total number of patients reported to have a difficult airway from 1992 to 2006.

surveys that examined airway management of trauma patients in the emergency room reported a cricothyrotomy incidence of 0.3 and 0.9%.[19,20] Chang et al.[21] compared the rate of cricothyrotomy performed on trauma patients before and after the implementation of an emergency medicine residency and found a decrease in the surgical airway rate from 1.3% to 0.2%. We had data on the total number of anesthetics but not on the total number of intubations. Instead, we examined the risk of requiring a surgical airway for those reported to have difficult airways by comparing the average number of difficult airways to the number of surgical airways for each time period. The results point to a reduction of surgical airway risk from 2.5 per 10,000 cases to 0.5 per 10,000 cases.

Our program incorporated many of the components recommended by Showan and Sedutto[16] with good results. We believe that the combination of teamwork, training, oversight, and patient education resulted in improved outcomes. Because of the lack of a control group, we can only show a temporal relationship between the implementation of the airway program and a decreased incidence of surgical airway.

Although we believe that equipment and education were key factors in reducing the need for emergency surgical airways, the difficult airway reporting system also played an important role. Knowledge of a patient's airway history preoperatively may have contributed to the ability to plan appropriately and potentially avoid a life-threatening airway problem. Anticipation and preparation for a difficult airway and intubation can potentially reduce the incidence of surgery cancellations, adverse outcomes, malpractice claims, and loss of life. The ability to access patient information at any time was essential to obtain this goal. A secure web-based reporting system allowed a practitioner to access this information as well as to enter information about a patient from any location with the appropriate network access. The slight increase in the number of planned awake intubations in patients assessed to have a difficult airway could be attributed to better knowledge of patients' airway histories preoperatively, as well as to an increased availability of equipment and improved education.

Our reporting system taught us many important lessons. The system was and continues to be voluntary; hence, it is possible that not all difficult airways were entered into the database. The definition of a difficult airway varies in the literature as well as among practitioners, so some patients with difficult airways may not have been reported and others may have been unnecessarily reported. With increasing awareness of the difficult airway reporting system, improved difficult airway management techniques with standardized algorithms, and the introduction of new airway devices, the reporting of a difficult airway by practitioners may have changed over time. It is possible that fewer awake intubations were performed as a result of newer airway devices becoming available and more "difficult airways" were uncovered after patients received general anesthesia. Providers may not have reported a patient as a difficult airway if awake intubation was chosen as the primary technique and no difficulty was encountered.

We closely reviewed the database for duplicate reports on patients and reported each patient only once, even though a particular patient may have presented several times for an anesthetic after being diagnosed with a difficult airway. Before the creation of a more comprehensive electronic database in 2005, some datasets were incomplete because the information was acquired from a combination of provider reporting (via phone or email) and chart review. After 2005, more specific details regarding the management of a patient's airway were entered directly by the provider, but reporting decreased, possibly due to the learning curve associated with new technology, a few early computer program "glitches" in the system, and the time required to enter the data. With continued education on usage of the web-based reporting system and the ability to enter data from any location, including the OR, providers were more likely to enter patient information into the system. Providers also received feedback on reports and found the difficult airway

notes in the hospital's EPR to be very useful when patients returned to the OR for further procedures. Katz and Lagasse[22] studied factors influencing reporting of adverse outcomes and found that physician self-reporting was a reliable method and that reporting reached a stable rate after a year.

The variability in the number of reported difficult airways over time could also be related to the type of reporting system used. We noticed an increase in the number of reported difficult airways with the introduction of a 24-h pager for reporting; it is not clear whether this increase was due to the ease of reporting or a true increase in the number of difficult airways during that time period. The change in number of reports may also have been influenced by the increased use of the LMA and the development of less invasive surgical procedures for which endotracheal intubation is not required, leading to a reduction in the identification of difficult airways. But this is speculation; we do not currently have data to support this conclusion. It is unlikely that the number of emergency surgical airways were underreported because the anesthesiology staff, as well as the nursing and surgical staff, are fully cognizant that these cases are reportable adverse events.

The reporting system had other limitations. It was resource-intensive, requiring personnel to enter a report into the database as well as into the EPR because the two are not linked. The difficult airway alert on the OR schedule required an additional entry by those who manage the surgical posting. Having all of these systems linked would be ideal, but currently the information is entered separately and often by different people.

Equipment was an important feature of this program. The decrease in need for an emergency surgical airway procedure was temporally related to the availability of standardized equipment and personnel educated in its use. Support for this type of equipment is stated in the recommendation of the *American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway* to have at least one portable storage unit that contains specialized equipment for the difficult airway.[1]

Although most general OR suites have a variety of airway management equipment both for anesthesiologists and surgeons, each piece of equipment may be located in a different area. Thus, it takes time and effort to locate and deliver the necessary device. When a difficult airway is encountered, time is of the essence, particularly if the patient is not only difficult to intubate but also difficult to ventilate. Having most of the equipment needed for advanced airway management in one cart facilitates availability of the equipment in a timely manner. The availability of a difficult airway cart may have an even greater impact in areas outside a general OR suite. A general OR often has advanced airway equipment available for surgical use. Nonoperative areas, obstetric suites, and emergency departments may not otherwise have equipment for airway management immediately available. A survey of obstetric units in Germany revealed that most units had laryngoscopes and LMAs but were less likely to have a flexible bronchoscope or the means to deliver transtracheal ventilation.[5] Surveys of emergency departments in the United Kingdom showed that they were more likely to have a surgical airway device as an alternative to laryngoscopy than a flexible bronchoscope or LMA.[6–8]

The cost of this program included the purchase of the carts, equipment, and supplies and the salaries of the staff needed to sustain the program. The approximate costs were contents of the cart $2500, the flexible bronchoscope $8000, and the cart itself $1140, totaling $11,640 for a fully-stocked cart. The technical support for all locations required approximately 70% of a full-time support employee during the day, 30% of a full-time support employee in the evening and a night/weekend call-in 3–4 times a week. The cost of the anesthesiology and surgical staff to support the program was estimated to be a minimum of one full day per week or approximately $50,000 per year for each service.

It was crucial to have personnel available to maintain the carts. The airway carts were often used several times a day, including nights and weekends. Consequently, knowledgeable support staff was required to be available at all times. Because usage of the carts is usually reduced on nights and weekends, we found that having support staff on-call (as opposed to in-house) for cart cleaning and restocking during the low usage times was adequate.

Several studies have indicated that a difficult airway educational program for trainees (residents) may be beneficial for preventing serious airway complications.[13–15] Such programs provide greater exposure to advanced airway techniques and a uniform knowledge base for the trainee. Knowledge of difficult airway management guidelines and algorithms is an expected outcome of an educational program.[1,23] Our program benefits not only the anesthesiology residents but also the attending staff. The availability of experienced staff to aid a less experienced anesthesia team that is caring for a patient with a difficult airway allows that team to be exposed to airway management techniques they may not otherwise have encountered. In addition, simulated training on mannequin models increases exposure to new airway devices as they are introduced to the system. Several surveys of anesthesia training programs in the United States and Germany revealed that only approximately one-third offer a formal airway rotation.[14,24,25] A recent study by Kuduvalli et al.[26] demonstrated that difficult airway education using a simulation model led to improved performance during management of the unanticipated difficult airway for at least 6–8 wk after training.

All anesthesiology staff had access to educational equipment and a variety of airway devices to practice

flexible bronchoscopy and other techniques using methods that have been shown to be effective teaching techniques.[12–15] The database showed an overall trend toward an increased number of awake intubations performed by flexible bronchoscopy after the program began. The increase could be attributable to the staff feeling a greater comfort level with using this equipment as a result of the educational aspect of the program or could be related to increased availability of equipment.

We have found that education of the patient with a difficult airway may be vitally important for future anesthetic planning. Patients who know their history and can provide a letter from an anesthesiologist detailing how their airway was managed in the past are tremendously helpful. In a few difficult airway cases, the patients were unaware that they had a difficult airway history, but we discovered after the event that a family member knew the patient's history but was not available during the preoperative evaluation. For this reason, we now send a letter to patients with difficult airways and instruct them to bring it with them for any future procedures that require anesthesia.

We continue to encounter patients with difficult airways who require an emergency surgical airway because of inability to intubate and ventilate. We believe this will continue to be the case, despite the difficult airway program and the availability of newer airway devices. Thus, an emergency cricothyrotomy kit is available on the difficult airway cart. Of the patients in our database who had an emergency surgical airway in the past decade, approximately 30% required the procedure shortly after extubation or in the early postoperative (postextubation) period because of airway edema. We have emphasized this issue in our educational programs.

The inability to intubate and ventilate often results in a crisis situation, and thus crisis management skills should be considered part of an airway educational program. Although we did not specifically include this in our initial program, team building is now becoming an important part of our perioperative training program and includes all members of the health care team. Future studies are needed to develop effective programs that use high-fidelity patient simulators to teach technical and crisis management skills.

In conclusion, a "best practice" for managing the difficult airway includes the availability of patient information, a system for preoperative evaluation, on-going education of the health care team, simulated teaching of technical skills, advanced airway equipment immediately available with support staff to manage it, well-established algorithms with decision-making trees that can aid in patient management during crisis situations, and education of the patients themselves.

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