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Title: Multi-Institutional Analysis of Outcomes in Supraglottic Jet Ventilation with a Team-Based Approach.

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Running title: Jet ventilation in laryngotracheal stenosis

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ABSTRACT:

Objectives: To evaluate the safety and complications of endoscopic airway surgery using supraglottic jet ventilation with a team-based approach.

Methods: Subjects at two academic institutions diagnosed with laryngotracheal stenosis who underwent endoscopic airway surgery with jet ventilation between January 2008 and December 2018 were identified. Patient characteristics (age, gender, race, follow-up duration) and comorbidities were extracted from the electronic health record. Records were reviewed for treatment approach, intraoperative data, and complications (intraoperative, acute postoperative, and delayed postoperative).

Results: 894 patient encounters from 371 patients were identified. Intraoperative complications (unplanned tracheotomy, profound or severe hypoxic events, barotrauma, laryngospasm) occurred in fewer than 1% of patient encounters. Acute postoperative complications (postoperative recovery unit [PACU] rapid response, PACU intubation, return to the emergency department (ED) within 24 hours of surgery) were rare, occurring in fewer than 3% of patient encounters. Delayed postoperative complications (return to the ED or admission for respiratory complaints within 30 days of surgery) occurred in fewer than 1% of patient encounters. Diabetes mellitus, active smoking, and history of previous tracheotomy were independently associated with intraoperative, acute, and delayed complications.

Conclusion: Employing a team-based approach, jet ventilation during endoscopic airway surgery demonstrates a low rate of complications and provides for safe and successful surgery.

Key words: jet ventilation, airway management, laryngotracheal stenosis, subglottic stenosis, tracheal stenosis, difficult airway.

Level of evidence: Level 4

INTRODUCTION:

Laryngotracheal stenosis (LTS) is defined as luminal compromise at the level of the larynx or trachea that physiologically inhibits ventilation, resulting in dyspnea. A mainstay of diagnosis and management for LTS is operative endoscopy with endoluminal interventions, including lysis or excision of scar, delivery of adjuvant medications, and dilation. Due to the nature of the airway obstruction, these patients are often difficult or impossible to intubate at induction of anesthesia, resulting in significant intraoperative and postoperative risk of respiratory complications[1,2]. There is considerable variation of airway management strategies and operative ventilation techniques across centers, including awake tracheotomy, fiberoptic intubation, intermittent intubation with apneic intervention, transnasal humidified rapid-insufflation ventilation exchange, and jet ventilation, among others[3-5].

Jet ventilation is a ventilatory technique in which a catheter passes a thin, high velocity stream of air into the lungs followed by passive exhalation[6]. Jet ventilation offers several advantages for endoluminal airway surgery, including improved surgical exposure from lack of an obscuring endotracheal tube and reduced surgical time as ventilation can occur concurrent with the procedure[7]. However, complications can be life-threatening, including hypoxemia, hypercarbia, laryngospasm, barotrauma, and airway obstruction[2]. As such, there is hesitancy to employ the technique in many centers[1,2,7-10]. A consistent and cohesive airway team incorporating surgical and anesthesia personnel along with experienced operating room staff is required to effectively treat and protect this unique patient population[11,12].

We hypothesized that a collaborative airway team including experienced otolaryngology and anesthesia personnel mitigates risk compared to historical norms when employing advanced ventilation techniques such as supraglottic jet ventilation for treatment of LTS. The primary aim of this study was to define the incidence of complications with the use of supraglottic jet ventilation for endoscopic treatment of LTS at high-volume institutions employing multidisciplinary airway management teams. In addition to the overall safety of jet ventilation, we investigated the associations of patient factors and procedural factors on the incidence of complications.

PATIENTS AND METHODS

This study was performed in accordance with the Declaration of Helsinki, Good Clinical Practice, and was approved by institutional review boards at both participating centers (Vanderbilt IRB 190102, Michigan IRB HUM00154272).

Patients

Patients with a diagnosis of laryngotracheal stenosis (ICD-9: 478.33, 478.74, 519.19, 519.02; ICD-10: J38.02, J38.6, J39.8, J95.03) who underwent endoscopic airway procedures employing supraglottic jet ventilation between 2008 and 2018 at Vanderbilt University Medical Center (VUMC) and the University of Michigan (UM) were identified. Cases were identified using procedural codes (CPT 31528, 31541, or 31630) and the UM cohort was collated using the Electronic Medical Record Search Engine (EMERSE) to elicit pertinent inclusion diagnoses[13]. Any patient with the aforementioned diagnoses who underwent endoscopic intervention with primary use of supraglottic jet ventilation was included in analysis. Cases which also employed use of the carbon dioxide (CO_2) laser were included. Jet ventilation was employed using low-frequency hand jet control at VUMC. The average pressure of low-frequency jet ventilation was sustained at a maximum of 20 psi. The rate was regulated by the anesthesia provider and averaged in the range of normal respiration, 12-16 breaths per minute. The high-frequency Monsoon system (Acutronic Medical Systems AG, Hirzel, Swizerland) was primarily used at UM. The standard settings for the Monsoon system, which were rarely altered, included a driving pressure of 24 psi, rate of 120 ventilations/minute, inspiratory time of 40%, peak inspiratory pressure limit of 28 cm H_2O, and peak pause limit of 24 cm H_2O. Exclusion criteria included pre-operative presence of tracheostomy or planned tracheotomy, absence of supraglottic jet ventilation as a primary intended ventilatory technique during the operation, and airway diagnoses besides LTS, such as malignancy, papilloma, or foreign body.

Data Collected

Patient demographics including age, race, gender, height, weight, body mass index (BMI), and medical comorbidities were evaluated. Patients were listed as active smokers if they were actively smoking or had quit smoking within one month prior to the procedure. Intraoperative data points included total operative time, total anesthetic time, anesthetic type, use of neuromuscular blockade, and intraoperative application of laryngotracheal anesthetic (LTA).

Outcomes

The patient record was reviewed for evidence of complications, including the intraoperative, in-patient, and ambulatory record. Complications were categorized as (1.) Intraoperative events: need for unplanned tracheotomy due to loss of ability to ventilate the patient, need for intubation or laryngeal mask airway (LMA) placement, prolonged (SpO_2 <70% for >60 seconds) or profound (SpO_2<50%) hypoxic event, pneumothorax, and laryngospasm. (2.) Acute postoperative events (<24 hours postoperative): PACU respiratory events requiring use of positive airway pressure (PAP) therapy, nebulizers, or racemic epinephrine, rapid response, reintubation, or return to the ED with respiratory complaints within 24 hours of surgery. 3.) Delayed postoperative events (>24 hours and <30 days post-operative): return to the ED or need for hospital readmission due to respiratory symptoms. Major complications were defined as the need for an unplanned tracheotomy, intraoperative or postoperative pneumothorax, prolonged or profound hypoxic event, and reintubation in the PACU. All other complications were categorized as minor. Scheduled admissions as well as incidence of unplanned admissions or unplanned escalation in level of post-operative care were documented. Each surgery was considered a unique data point, even if a subject underwent multiple operations during the study period.

Statistical Analysis

Statistical analysis was performed using STATA version 15.1 by StataCorp LLC (College Station, TX, USA). For all variables analyzed, statistical significance was defined as $P<0.05$. Univariate testing was performed using chi-squared analysis for categorical values and Mann-Whitney U tests for comparison of medians. Multiple regression analysis was performed using the variables age, race, obesity, previous tracheostomy history, diabetes mellitus, smoking history, coronary artery disease (CAD), and chronic obstructive pulmonary disease (COPD). Beta-coefficients were used to determine the extent to which each factor contributed to both intraoperative and postoperative respiratory events.

RESULTS:

Baseline Characteristics

The study included a total of 894 surgical encounters (n= 647 from VUMC and n= 247 from UM) from 371 subjects with the diagnosis of LTS who underwent endoscopic airway surgery with supraglottic jet ventilation from January 2008 - December 2018 (Table I). There were 743 females (83.1%) and 151 males (16.9%). The average body mass index (BMI) was 29.3 (minimum/maximum = 24.0 - 34.5). Average age was 52.7 years (IQR: 43.8-61.9). Patient race was predominantly Caucasian (94.9% Caucasian, 3.4% African American, 1.7% represented by other races. The number of patients that required intraoperative endotracheal intubation was significantly higher in patients with diabetes than patients without the disease (44.4% vs 30.8%, $p<0.001$). African American patients were more likely than Caucasian patients or patients of other races to require unplanned intraoperative tracheotomy (3.33% vs. 0.24% vs. 0.00%, respectively, $p=0.02$). Two hundred and fourteen cases (24.1%) were scheduled for admission prior to surgery, and 2 cases (0.2%) were admitted unexpectedly or had an unexpected escalation in level of care on admission.

Intraoperative and Anesthetic Management

Six hundred and seventy-one cases (75.1%) used total intravenous anesthesia exclusively. Two hundred and twenty-three cases (25.1%) used both intravenous and inhalational anesthesia. The vast majority of cases (n=833, 93.8%) utilized muscle relaxation (non-depolarizing medication = 745 cases, 83.3%; succinylcholine = 24 cases, 2.7%; and both succinylcholine and a non-depolarizer = 65 cases, 7.3%). A reversal agent was used in all cases using muscle relaxation. Neostigmine was the most common agent (n=510, 61.2%) followed by sugammadex (n=245, 29.4%). Laryngotracheal anesthesia was applied in 577 cases (64.5%). Operative time was utilized as a surrogate for total jet ventilation use per case and the average duration was 74 minutes (IQR 58-92 minutes).

Intraoperative Complications

Intraoperative complications were extremely rare, occurring in 1.7% of patient encounters, including laryngospasm (n=8), prolonged hypoxic event (n=4), unplanned tracheotomy due to loss of ability to ventilate the patient (n=3), and pneumothorax (n=1). Three of the patients that experienced laryngospasm required reintubation to secure the airway with subsequent successful extubation during the same surgical procedure. No profound (SpO2<50%) hypoxic events occurred. Adjuvant ventilatory techniques including endotracheal intubation or placement of LMA were employed after initiation of jet ventilation in 351 (39.3%) cases. The rate of complete failure of jet ventilation to maintain oxygen levels, requiring either urgent intubation or tracheotomy, was low (0.67%, urgent intubation n=3, tracheostomy n=3).

Post-operative Complications

PACU events: Patients spent a median of 87 minutes (IQR: 58-126 min) in PACU. Respiratory-related events in the PACU requiring intervention occurred in 27 cases (3.0%); unexpected admission resulted in 12 of these cases (1.4%). Interventions in the PACU included racemic epinephrine (n=9), facemask oxygen (n=4), albuterol nebulizer (n=4), intubation (n=4), PAP therapy (n=1), and rapid response (n=1). No laryngospasm or pneumothoraces were identified in the PACU.

24-hour events: Return to the ED within 24 hours of surgery for respiratory events that required escalation of care occurred in nine cases (1.0%), including use of a supplemental oxygen via facemask in three cases (0.34%), intubation in two patients (0.23%), otolaryngology consultation in two cases (0.23%), and use of racemic epinephrine in one case (0.11%), In two cases, the patients were admitted from the ED (0.23%). PAP therapy and albuterol nebulizer therapy were not used. No pneumothoraces were reported.

Delayed Post-operative Complications: Return to the ED within 30 days of surgery with respiratory complaints occurred in 17 cases (1.9%). Readmission to the hospital within 30 days of surgery due to respiratory complaints occurred in 26 cases (2.9%). The most common reason for readmission was recurrence of dyspnea or stridor. There was one case of delayed subcutaneous emphysema.

Overall Complications and Univariate Analysis for Predictors of Complications

The overall complication rate was 5.4% (n=48). The majority of complications were delayed post-operative complications (Table II). Major perioperative respiratory complications including tracheotomy, intraoperative or postoperative pneumothorax, severe hypoxic event, prolonged hypoxic event, and PACU reintubation occurred in four cases (0.5%). BMI was not correlated with complication rate (p=0.58). Active smoking was associated with a higher incidence of complications compared to non-smokers (11.0% vs. 4.91%, p=0.03). Patients with history of tracheostomy had higher incidence of complications than those without history of tracheostomy (11.1% vs. 4.62%, p=0.005). Race was significantly associated with overall complications. Patients of other races were more likely to have both intraoperative and postoperative complications than Caucasian or African American patients (20.0% vs. 5.2% vs. 3.3%, respectively, p= 0.04). Increased OR time (mean 133 minutes vs. 80 minutes) was associated with the occurrence of both intraoperative and postoperative respiratory events (p=0.01).

Anesthetic Factors: use of a non-depolarizing muscle relaxant was associated with a lower incidence of both intraoperative and postoperative complications than use of both a non-depolarizing muscle relaxant and succinylcholine or succinylcholine alone (4.4% vs. 13.8% and 12.5%, respectively, p=0.001). There was no difference in the rate of intraoperative or postoperative complications when comparing patients that did and did not receive LTA (5.0% vs. 6.1%, p=0.496)

Multivariable Logistic Regression Analysis for Predictors of Complications

Diabetes mellitus, history of smoking, and prior tracheostomy were found to be independently associated with increased likelihood of respiratory events based on multivariable logistic regression analysis (p=0.03, 0.04, 0.03, respectively). Other comorbidities including age, race, obesity, CAD, and COPD were not found to be significant in logistic regression analysis.

Discussion:

This multi-institutional retrospective cohort study over 10 years at two tertiary-care medical centers demonstrates the overall safety of supraglottic jet ventilation in treatment of LTS. In 894 patient encounters, intraoperative complications occurred in only 1.7% of cases. These included unplanned tracheotomy due to inability to ventilate the patient (0.3%), prolonged hypoxic event (0.4%), pneumothorax (0.1%), and laryngospasm (0.9%). Delayed complications were most commonly encountered (4.8%), including return to the ED within 30 days or hospital readmission due to respiratory issues. No deaths occurred. To our knowledge, this study is the largest to date evaluating the intraoperative and postoperative outcomes of this patient population using either low-frequency or high-frequency supraglottic jet ventilation as a primary ventilatory technique.

Previous studies on jet ventilation do not differentiate between supraglottic and subglottic ventilatory techniques nor have they studied exclusively supraglottic jet ventilation[1,2,7-10]. Since barotrauma in jet ventilation is largely assumed to be due to inadequate egress of air during passive exhalation with breath stacking, supraglottic jet ventilation would theoretically mitigate this risk.

The overall complication rate in our cohort was low (5.4%), which supports the safety of this ventilatory technique in endoscopic airway surgery, even in medically complex patients. Our results are in congruence with previous literature showing that outpatient endoscopic airway surgery did not result in higher complication rates compared to those that were kept for overnight observation[1]. The authors propose that many patients can tolerate discharge home after endoscopic airway surgery employing supraglottic jet ventilation. However, individualized care is still necessary as some higher risk patients may require overnight observation including smokers, patients with diabetes mellitus, or those with history of tracheostomy. Operative time was associated with increased respiratory events, which may be a direct effect or a surrogate for difficulty in intraoperative airway management and ventilation. As such, surgeons may have a lower threshold to admit patients with a particularly difficult or prolonged operative course.

Other important factors may also inform the decision on scheduled admission, including nature or complexity of the airway stenosis, patient distance from the treating facility, and patient or surgeon perception of safety. While the majority of cases in this study were performed as outpatient surgery, we are not advocating performance of surgery for laryngotracheal stenosis at an ambulatory surgery center (ASC). The level of team care required for these procedures is generally not available at an ASC and the potential complications, though uncommon, are best handled at a hospital-based facility where intensive-care level assistance is available if needed.

A team-based approach is the most effective and safest way to implement positive change in a system[13,14]. A cohesive, experienced airway team comprised of a knowledgeable anesthesiologist, surgical technician, nursing staff, and otolaryngologist are important to the safety and efficiency of care in management of LTS, however, clear communication and collaboration between all members of the team and clear establishment of the role of each team member prior to beginning the procedure is of utmost importance. In a study by Matrka et al., a standardized communication protocol was consistently followed, and the complication rate remained low despite the experience of the airway team[15]. Our results demonstrate a cohesive airway team mitigates many of the risks of advanced ventilatory techniques like jet ventilation in surgery for LTS.

One should consider the comorbidities of the patient when considering surgical intervention in LTS. Our study does not demonstrate an increased risk of complication with elevated BMI in jet ventilation, consistent with prior literature[16-18]. However, selection bias and avoidance of jet ventilation for most-obese patients may confound results. Although end-tidal CO_2 tends to increase intraoperatively with increasing BMI, this has not been correlated with any significant complications to date[16-18]. It should also be noted that cardiovascular disease was not found to be associated with either intraoperative or postoperative respiratory complications in our cohort of patients. However, cardiovascular disease has previously been found to be an independent risk factor related to both intraoperative and postoperative complications in management of LTS and should be taken into consideration prior to proceeding with surgery[8].

Although several types of ventilation have been studied in treatment of LTS, this study supports supraglottic jet ventilation as a consistent and safe ventilation method. Complications of jet ventilation including pneumothorax and laryngospasm occurred very rarely in our study (0.1%

and 0.9%, respectively). Despite use of the CO_2 laser in many of the recorded procedures, there were no reported airway fires. Previous studies have demonstrated similar risk of barotrauma and laryngospasm with transtracheal and subglottic jet ventilation as well as the risk of laryngospasm with apneic intermittent ventilation[1,2,7-10,19]. The surmised benefit of supraglottic over subglottic jet ventilation is the absence of any transglottic catheter that may impede visualization in the operating field or obstruct egress of air, potentially leading to pneumothorax.

One third of cases involved the use of adjuvant intubation in addition to jet ventilation. It is important to note that intubation was employed most often to aid in the procedure and not due to a failure of jet ventilation to maintain normoxia. Most often, this was performed via intubation through the laryngoscope to size the airway post-intervention, optimize oxygenation prior to apnea and dilation, reduce atelectasis via lung recruitment breaths, limit hypercarbia, or secure the airway during anesthesia emergence. The use of intubation as a rescue due to desaturation of the patient despite attempts at jet ventilation was significantly less common (n=3, 0.34%). As such, the need for intubation in the midst of jet ventilation should not be seen as a failure of the ventilatory technique. In addition, having a team familiar with a variety of airway management techniques allows for rapid use and alternation between different airway management techniques such as intubation and jet ventilation.

The hospital readmission rate of 2.9% within 30 days of surgery may be misleading as readmission to the hospital was most often due to primary treatment failure and disease recurrence rather than a direct complication related to the initial surgery. Therefore, all readmissions do not represent unforeseen complication related to the jet ventilation.

This study has several limitations. Differing behavior in regard to intraoperative intubation makes this variable difficult to interpret. There is potential selection bias against patients who may not tolerate supraglottic jet ventilation due to surgeon perception of which patients may tolerate the ventilatory technique, such as patients with high BMI or the type of jet ventilation system available. Patient follow-up varied at both institutions. Most patients returned to clinic for routine follow-up within 1 month of surgery. However, some patients did not follow up until they presented months later in airway distress or were lost to follow-up altogether. Outside ED visitation was only accounting for if noted in ambulatory documentation at the two institutions. Because complications were rare in this study, the study may be insufficiently powered to assess for complications related to certain comorbidities. Both centers in this study are high-volume airway centers, which may affect documented complications. Nurses in the post-anesthesia care unit may be more comfortable managing complex airway patients than staff in a lower-volume environment. Thus, complication rates may not be generalizable to all centers.

Conclusion:

We present the largest series of 894 cases of endoscopic treatment of laryngotracheal stenosis using supraglottic jet ventilation. Active smoking, diabetes mellitus, and history of tracheostomy were significantly associated with an increased risk of perioperative and postoperative complications. We have identified several key elements that result in successful treatment of this group of disorders with a low overall complication rate (5.4%) and low unplanned tracheotomy rate (0.3%). A team-based approach is essential in managing this patient population. Supraglottic jet ventilation during endoscopic airway surgery is a safe airway management technique with a low risk of intraoperative and postoperative complications. These cases are best performed in a hospital-based setting.

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Table I. Baseline Characteristics	Complications* (n=48)	No Complications (n=846)	Total (n=894)	Significance (p)
Demographics				
Gender, N (%)	48 (100)	845 (99.9)	894 (100)	0.72
Male	9 (18.8)	142 (16.8)	151 (16.9)	
Female	39 (81.3)	703 (83.1)	743 (83.1)	
Age, median years (IQR)	51.38 (33.90-61.46)	52.75 (44.07-61.87)	52.66 (43.81-61.86)	0.16
Race, N (%)	48 (100)	846 (100)	894 (100)	**0.04**
Caucasian	44 (91.7)	803 (94.9)	843 (94.9)	
Black	1 (2.1)	31 (3.7)	30 (3.4)	
Other	3 (6.3)	12 (1.4)	15 (1.7)	
Weight, kg, median (IQR)	82.53 (62.3-98.0)	82.14 (65.80-96.00)	78.00 (65.30-96.10)	0.57
Height, cm, median (IQR)	165.17 (160.0-167.60)	165.26 (160.02-170.18)	165.1 (160.0-170.0)	0.97
BMI, kg/m^2, median (IQR)	30.32 (22.3-33.9)	30.09 (24.16-34.45)	29.3 (24.03-34.45)	0.58
Comorbidities, N (%)				
HTN,	22 (45.8)	26 (54.2)	316 (35.4)	0.12
CAD,	4 (8.3)	44 (5.2)	60 (6.7)	0.64
Diabetes	13 (27.1)	35 (4.1)	151 (16.9)	0.53
COPD	2 (4.2)	46 (5.4)	68 (7.6)	0.36
Active smoker	8 (16.7)	40 (4.7)	73 (8.2)	**0.03**
History of tracheotomy	12 (25.0)	36 (4.3)	108 (12.1)	**0.005**
Prior H/N surgery	16 (33.3)	32 (3.8)	432 (48.3)	**0.03**
Anesthesia Data				
Total OR time, min, median (IQR)	99.77 (65.5-120.0)	80.48 (24.0-76.0)	76 (62-94)	0.01
Anesthesia type, N (%)	48 (100)	846 (100)	894 (100)	0.5
TIVA, N (%)	38 (79.2)	633 (74.9)	671 (75.1)	
Both IV and inhalation, N (%)	10 (20.8)	213 (25.2)	223 (24.9)	
Use of muscle relaxant, N (%)	45 (93.8)	788 (93.2)	833 (93.2)	0.99

Muscle relaxant type, N (%)	45 (93.8)	788 (93.2)	833 (93.2)	**0.001**
Non-depolarizer, N (%)	33 (68.8)	712 (84.2)	745 (83.3)	
Succinylcholine, N (%)	3 (6.3)	21 (2.5)	24 (2.7)	
Both non-depolarizer and succ, N (%)	9 (18.8)	56 (6.6)	65 (7.3)	
Reversal agent, N (%)	45 (93.8)	788 (93.5)	833 (93.2)	0.64
LTA, N (%)	29(60.4)	548 (64.8)	577 (68.0)	0.5
Admission Data, N (%)				
Scheduled admission	23 (47.9)	25 (3.0)	214 (23.9)	**<0.001**
BMI = body mass index; HTN = hypertension; CAD = cardiovascular disease; COPD = chronic obstructive pulmonary disease; H/N = head and neck; OR = operating room; TIVA = total intravenous anesthesia; LTA = laryngotracheal anesthesia Complications*= Includes both intraoperative and post-operative complications				

Table II. Intraoperative and Postoperative Complications	No. of Cases (n= 894) (%)
Intraoperative Complications	
Intraop tracheotomy, unplanned, N (%)	3 (0.3)
Lowest oxygen saturation intraop, median (IQR)	92.0 (90-97)
Intraop LMA or Intubation, N (%)	351 (39.5)
ETT	294 (33.1)
LMA	74 (8.3)
Prolonged hypoxic event, N (%)	4 (0.5)
Severe hypoxic event (IQR)	0 (0)
Pneumothorax, N (%)	1 (0.1)
Laryngospasm, N (%)	8 (0.9)
PACU Complications, N (%)	
Respiratory event requiring escalation of care	27 (3.0)
Facemask	4 (0.5)
BiPAP/CPAP	1 (0.1)
Albuterol Nebulizer	4 (0.5)
Rac Epi	9 (1.0)
Reintubation	4 (0.5)
Other (includes nasal cannula, sedation, reintubation, IV steroids)	5 (0.6)
Unplanned admissions	12 (1.3)
Rapid response in PACU	1 (0.1)
Total PACU Complications	27 (3.0)
Immediate Post-Operative Complications, N (%)	
Return to ED <24 hours	1 (0.1)
Respiratory Event in ED requiring escalation of care- FIX NUMBERS	9 (1.0)
Facemask	3 (0.3)
PAP therapy	0 (0)
Albuterol Nebulizer	0 (0)
Rac Epi Neb	1 (0.1)
Intubation	2 (0.2)
ENT Consultation	2 (0.2)
Other (includes nasal cannula, sedation, IV steroids	4 (0.5)
Pneumothorax	0 (0)
Admission from ED	2 (0.2)
Total Immediate Post Op Complications	9 (1.0)
Delayed Post-Operative Complications, N (%)	
ED visit 1-30 days	17 (1.9)

Admission 1-30 days	26 (2.9)
Admission 1-30 days WITHOUT repeat surgery	7 (0.8)
Total Delayed Post-operative Complications	18 (2.0)
Intraoperative and Postoperative Complications (all phases of care), N (%)	48 (5.4)
LTA = laryngotracheal anesthesia; ED = emergency department; LMA = laryngeal mask anesthesia; ETT = endotracheal tube; SpO2= peripheral oxygen saturation; PACU = post-anesthesia care unit; PAP = positive air pressure	