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Management of Difficult Airway among Patients with Oropharyngeal Angioedema

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Abstract

Objective: The objective of our study was to assess the impact of a multidisciplinary Difficult Airway Response Team (DART), a quality improvement program, in the management of patients with difficult airway associated with oropharyngeal angioedema patients.

Methods: Individual retrospective cohort study. Retrospective review of patient charts from July 2003 to June 2008 (pre-DART) and retrospective review of prospectively collected data from July 2008 to June 2013 (post-DART). Patients with angioedema were identified using CPT codes 995.1 and 277.6. Patients were included in the study if an otolaryngologist was consulted for airway management. Patients were excluded if they had a history of angioedema but no active issues. Patient characteristics, airway evaluation, and interventions (intubation/surgical airway) were compared between the pre-DART and post-DART cohort.

Results: The DART team attended to 27 patients with advanced oropharyngeal angioedema. Response time averaged 3.36 minutes. Pre-intubation fiberoptic airway evaluations were performed in 81% of the post-DART cohort and 56% of the pre-DART cohort. The incidence of patients requiring intubation was higher in the post-DART cohort (18 out of 27 [67%]) than the

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pre-DART (14 out of 36 [39%]) cohort. One emergency cricothyroidotomy was performed in each of the post-DART and pre-DART cohorts.

Conclusion: Angioedema of the larynx is a predictor of intubation or cricothyroidotomy. Fiberoptic-guided intubation is primarily used for establishing airway in angioedema patients. A multidisciplinary standardized approach such as the DART program offers adequate time and resources for airway evaluation prior to intervention, and allows fewer number of attempts to secure an airway.

Keywords

Oropharyngeal Angioedema; Difficult Airway; Multidisciplinary; Airway Techniques; Clinical Outcomes

Introduction

Angioedema is the swelling of the subcutaneous and submucosal regions of the body that occurs with extravasation of plasma into interstitial spaces due to increased vascular permeability.¹ Regardless of the underlying pathophysiology, kallikrein-kinin- or histamine-induced angioedema, patients may be at risk for subcutaneous and submucosal swelling in the oropharyngeal region.^{2–5} The rate of admissions to emergency departments with primary oropharyngeal angioedema has increased from 29.3 in 2006 to 35.8/100,000 people in the United States in 2010.² Of particular relevance to practicing Otolaryngology-Head and Neck Surgeons (OHNS) is advanced oropharyngeal angioedema, a potentially life-threatening condition necessitating urgent airway evaluation and intervention. It is estimated that 10 to 34% of patients presenting with angioedema to an Emergency Department require intubation.^{2,3,6–9} Advancing age and involvement of multiple oropharyngeal sites increase the need for airway interventions.^{6,9–12} Moreover, alterations in anatomical landmarks can significantly complicate the efforts to secure an airway and may require advanced airway interventions.¹³

In recent years, there is a growing emphasis on improved training, decision-making and inter-disciplinary collaboration to address the management of patients with difficult airways.¹⁴ To address this need at our institution, a Difficult Airway Response Team (DART) was established in 2008.^{15–17} We hypothesize that a DART utilizing a standardized approach facilitates shorter response time, and decreases the number of intubation attempts and surgical airways in patients with advanced oropharyngeal angioedema. The objective of our study was to assess the impact of DART, a quality improvement program, in the management of patients with difficult airway associated with oropharyngeal angioedema patients.

Materials and Methods

Study Design

An individual retrospective cohort study was conducted. A retrospective review of prospectively collected data was performed in an academic tertiary care center. Patients were divided into two cohorts: angioedema patients managed 5 years before and 5 years after the

institution of the DART program (pre-DART cohort: July 2003–to June 2008, and post-DART cohort: July 2008–June 2013).

Quality Improvement Program

The DART program utilized a multidisciplinary team approach involving expert physicians from the Departments of Anesthesiology, General Surgery, and OHNS.¹⁷ In addition to physicians, advanced practice providers, respiratory therapists, and nurses arrived at the site of call. A DART cart with specialized equipment such as fiberoptic scopes was made available for efficient airway evaluation and securement (Figure 1). Team members were educated on a standardized approach to managing angioedema patients during the Multidisciplinary Difficult Airway Courses offered by the DART program.

Sample

The inclusion and exclusion criteria were designed to restrict analyses to patients with severe angioedema extensive enough to warrant specialist input and/or airway intervention. Patients were included in the study if they had an ICD-9 code of 995.1 (angioneurotic edema), site involvement of the aerodigestive tract, were 18 years or older, and an OHNS consult was obtained indicative of concern for a difficult airway. Patient's medical records were reviewed by two independent practitioners to include only those with new-onset, active oropharyngeal angioedema requiring clinical management. Exclusion criteria comprised patients who had a history of angioedema but without active issues, or did not require any OHNS consult or airway intervention.

Data collection

Institutional Review Board approval was obtained for Non-Human Subjects Research/Quality Improvement type of study (NA_00089582) prior to data collection. The following patient characteristics were collected: age, sex, physical location of airway call, etiology for angioedema, anatomical site involvement, and the number of sites involved. Location refers to where the patient was physically present at the time of need for airway management and correlated to the location where the patient was at the time of DART activation for patients managed by the DART. Physical location of airway call was broadly categorized into floor/wards, emergency room, and intensive care units (ICU). The etiology for angioedema was classified into ACE-I, other medications such as penicillin, hereditary, idiopathic and food allergies. Site involvement included the following: lips, anterior tongue, floor of mouth, soft palate, base of tongue, pharynx, or larynx.¹¹

Data regarding the airway management included whether a formal fiberoptic airway evaluation was done to determine the need for an airway intervention or performed in conjunction with attempts to establish an airway, number of patients intubated, what methods were used to intubate, whether the attempt was successful, and which service performed the intubation. We also reviewed the charts to find out whether the patient was transported to the operating room for advanced airway interventions (intubation or surgical airway).

Statistical Analysis

Stata/InterCooled 14.2 was used to analyze the data.¹⁸ Descriptive statistics such as mean and standard deviations were calculated for parametric data while frequencies and percentages were calculated for categorical data. Comparative statistics included *t*-tests parametric data and Chi Square or Fisher's Exact tests for categorical variables depending on the cell size. Backward stepwise logistic regression analyses were used to identify the predictors of airway intervention.

Results

After reviewing 820 medical records, 62 patients met the inclusion criteria. Thirty six patients were identified in the pre-DART and 27 were in the post-DART cohort. The study flowchart describing allocation of patients into their respective cohorts are described in Figure 2.

Patient Characteristics

The mean age of patients was 54 years in the pre-DART and 50 years in the post-DART cohort. There was no statistical difference in the age, sex, and location of airway call between the pre-DART and post-DART cohorts. There were similar numbers of women and men in the pre-DART cohort, while there were more women in the post-DART cohort (Table 1). The majority of patients in the pre-DART and post-DART cohort were encountered with angioedema in the Emergency Department, 78% and 56%, respectively.

Among the pre-DART cohort, the most common etiology of angioedema was ACE-I (58.3%), followed by 'hereditary' (19.4%) and 'idiopathic' causes (11.1%). The most common etiology of angioedema in the post-DART cohort was medications such as Penicillin, Bactrim, and Metoclopramide (33.3%), followed by 'idiopathic' (29.6%), and ACE-I (25.9%). The etiology of angioedema was significantly different between pre-DART and post-DART cohorts ($p=0.003$) (Table 1).

Overall in ten years, patients with angioedema related to ACE-I predominantly presented to the Emergency Department (24 [55.8%]). Thirty six patients (57%) had a single site affected by angioedema, 25 (40%) had two sites involved, only two patients (3%) had three or more sites involved. Specific sites involved for each cohort are listed in Table 1. There was no statistical difference in the number or anatomic sites involved between the pre- and post-DART cohorts.

Airway Evaluation, and Intervention

Fiberoptic laryngoscopic airway evaluations were performed more frequently in the post-DART cohort ($n=22$ [82%]) than in the pre-DART cohort ($n=20$ [56%]) ($p = 0.03$). The number of patients who required pharmacologic management alone without any need for airway intervention is displayed in Figure 3. The type of medications administered for angioedema management is shown in Table 2.

In the 10 years studied, thirty-two patients required airway intervention. The number of patients who required airway intervention was higher among the post-DART cohort (18 out

of 27 [67%]) than in the pre-DART (14 out of 36 [39%]) ($p = 0.03$). The average time taken by the post-DART (3.4 minutes) to respond to calls was shorter than by the pre-DART (89.2 minutes) cohort ($p < 0.01$). Eleven patients (79%) in the pre-DART cohort were transported to the operating room while only 9 (50%) patients in the post-DART cohort were transported to the operating room for airway securement. The team that predominantly secured an airway was an otolaryngologist in both pre-DART (64%) and post-DART (67%) cohorts (Table 2). The service that finally established the airway did not significantly differ between the two cohorts.

The awake transnasal fiberoptic technique was used as the first choice to intubate patients with oropharyngeal angioedema more frequently in the post-DART (72.2%) than in the pre-DART cohort (42.9%). The first time rate of success in the securement of the airway was significantly higher in the DART cohort (77.8%) than in the pre-DART cohort (42.9%) ($p = 0.04$). The number of patients who required more than 2 attempts for airway securement was higher in the pre-DART cohort (8 [57.1%]) than in the post-DART (4 [22.2%]) cohort (Figure 4).

One patient in each of the pre- and post-DART cohorts received a cricothyroidotomy. The pre-DART patient had received multiple attempts of intubation by the Emergency Department physicians prior to otolaryngologists being contacted. By the time the otolaryngologist arrived, the patient's clinical situation had deteriorated significantly, requiring a cricothyroidotomy for a definitive airway. For the patient in the post-DART cohort, an early decision was made to manage the airway in the Operating Room; however, after two unsuccessful attempts with nasal fiberoptic intubation and worsening oxygen saturations, a cricothyroidotomy was performed. There were no airway-related deaths in either cohort.

The odds of requiring an airway intervention was six times higher among patients who had an oropharyngeal angioedema involvement of the larynx regardless of pre- or post-DART cohort, controlling for age, sex, and etiology of oropharyngeal angioedema.

Discussion

Our retrospective study revealed that angioedema involving the larynx is a predictor of intubation or surgical airway, and that the DART program allowed adequate time and resources for airway evaluation prior to airway intervention, increased the use of fiberoptic-guided intubation, and decreased the number of attempts required to secure an airway in angioedema patients with difficult airway.

Predictors of Airway Intervention

Angioedema involving laryngeal structures was a strong predictor of airway interventions. In a review of 367 angioedema patients in three tertiary hospitals, Tai et al. reported age, stridor, hoarseness, dysphagia, drooling, and multiple affected sites to be associated with intubation or tracheostomy.⁷ McCormick found involvement of 3 or more sites to be correlated with the need for airway intervention (39%).¹¹ Specifically, involvement of anterior or base of the tongue, and larynx correlated with the need for intubation or

tracheostomy.¹¹ In addition, Kieu found that involvement of the soft palate was also associated with the need for airway intervention. In our study, we did not have strict criteria for when to secure the airway instead are relying on a combination of clinical presentation and laryngoscopy findings. Involvement of laryngeal structures was found to be the only significant predictor of airway intervention, which is probably attributable to the study being limited to patients for whom an otolaryngologist was consulted. Patients without laryngeal angioedema were most likely successfully intubated by non-otolaryngologists.

Although not a predictor of airway intervention, etiology of oropharyngeal angioedema was noted to be significantly different between the pre- and post-DART cohorts. Tai reported ACEI and angiotensin receptor blockers to be the primary inciting factor (49%).⁷ The difference in etiology between our two cohorts correlated with the location of initial presentation with angioedema, a factor that is not alluded to in Tai's study. A majority of patients in the Emergency Department (n=24 [56%]) presented with oropharyngeal angioedema related to ACE-I while those on the ICUs and floors presented with angioedema due to other medications (n=8 [40%]) or idiopathic reasons (n=5 [25%]). It could be postulated that patients receiving ACE-I are monitored closely and that anaphylactic reactions are identified and managed efficiently in the ICUs or floors compared other medications that are not as prone to cause a problem.

Decreased Time to Airway Management

At our institution, the time to respond to an airway emergency has decreased significantly since the establishment of the multidisciplinary DART program.¹⁷ Safe management of progressive, symptomatic oropharyngeal angioedema requires early recognition by clinicians and expedient intervention by specialists well versed in various intubation techniques. In most hospital systems across the United States, response teams exist to manage patients with cardio-respiratory emergencies, strokes, and trauma.^{19–26} While it is acknowledged that the vast majority of intubations are routine, a certain subset of airways are classified as difficult and represent a complex interaction between patient factors, clinical setting, and the skills of the practitioners.¹³ The unique feature of the DART program that facilitated shorter response time was the creation of a unified paging system that activated airway experts from all departments and equipment from all locations effectively.

Adequate Time for Airway Evaluation Using Fiberoptic Scopes

Easier access to the DART cart (Figure 5) offered the team sufficient time to perform an airway evaluation using flexible a fiberoptic laryngoscope prior to establishing a plan of care. In the pre-DART era, Otolaryngology residents had to travel to obtain a fiberoptic laryngoscope prior to responding to the consult, a contributing factor in the longer response times. The DART carts placed at strategic locations hospital-wide for easier access had an armamentarium of intubation-related equipment including rigid and fiberoptic scopes.¹⁷ When a DART was activated, the charge nurse brought the DART cart to the site of call and the respiratory therapist set up the fiberoptic scope so that it was ready for use upon airway experts' arrival. Well-designed difficult airway carts have been shown to reduce non-value-added time and walking distance to retrieve the equipment.²⁷ While the number of difficult

airway carts needed in operating suites has been recommended as one cart for every 15–20 anesthesia sites, the number of difficult airway carts needed outside the operating suites and how they should be strategically located have not been formally studied.²⁸

Effective airway evaluation using the right equipment facilitates the development of a definitive airway plan and backup alternatives for patients who require intubation. Alternatively, fiberoptic laryngoscopy can aid in the identification of the subset of patients with only soft palate, base of tongue, or posterior pharyngeal wall involvement without severe obstruction of the glottis or a need for emergent airway intervention. In such patients, pharmacologic management, care in a monitored setting, and serial examinations until no further progression of angioedema is observed could be implemented.¹² A higher rate of success of first intubation (78%) among the post-DART cohort could be a function of initial fiberoptic laryngoscopy evaluation (Figure 4). Moreover, the uniform use of awake fiberoptic guided intubation (72%) was likely informed by initial airway evaluation.

Standardization of Airway Management Approach

Awake transnasal fiberoptic-guided intubation was used more commonly as the first choice of airway securement technique in our study. In a study of 33 angioedema patients comparing different techniques of intubation, Wood proposed that videolaryngoscopy could be used to intubate faster without an increase in adverse events compared to fiberoptic bronchoscopy.²⁹ Although, videolaryngoscopes are available in our armamentarium, fiberoptic laryngoscopy proved to be the most successful in securing an airway in our patients.

Since the inception, the DART program has managed 360 adult difficult airways representing 8% of all code activations within the Johns Hopkins hospital system using a standardized approach.¹⁷ The DART program has also offered 23 multidisciplinary difficult airway courses, training 499 clinicians from various specialties (including 53 residents from OHNS) on the standardized approach to managing difficult airways involving especially advanced oropharyngeal angioedema.³⁰ Specific components related to airway management of oropharyngeal angioedema include didactic lectures, hands-on sessions to become competent in using both flexible and rigid fiberoptic scopes, and surgical airways, and high-fidelity simulation that enhances team-building among clinicians from various disciplines.³⁰ In our study, as a result of these educational efforts, the availability of equipment, and the timely arrival of airway experts such as otolaryngologists, a standardized approach is typically implemented using the awake transnasal fiberoptic method as the first choice for securing the airway in patients with oropharyngeal angioedema although variations may exist.

Decrease in the number of attempts to secure Airway

A higher number of patients requiring airway securement among the post-DART cohort suggests that DART functions by appropriately identifying the sickest patients who require intubation or surgical airway the most. However, the number of attempts taken to intubate a patient with angioedema was fewer when DART was involved. The decrease in the number of attempts can be associated with the higher rate of success of first attempt among the post-

DART cohort. This can be attributed to early recognition of difficult airway, effective activation of the DART, timely response of airway experts such as otolaryngologists, team collaboration, and easier access to resources. Early recognition was obtained by the multidisciplinary airway course education, alerts in the hospital electronic medical documentation system, and placement of identification bracelets on patients with oropharyngeal angioedema. It is also possible that the increased rate of airway intervention post-DART may be attributed to a lower threshold to intubate prompted by education and awareness of airway safety. Lastly, given the evidence that the earlier use of fiberoptic scopes can decrease the number of attempts required to establish an airway among patients with advanced oropharyngeal angioedema, we feel it is crucial to include fiberoptic scopes in the difficult airway carts.

Adoption of a Multidisciplinary Airway Team

Hospitals recognize the need for a multidisciplinary DART, however, the make-up of that team may be challenging because of the lack of in-house availability of some of the services, especially OHNS. Though, our hospital has a resident present in the hospital at all times, we feel our multidisciplinary airway team model may be adopted by hospitals that do not have in-house OHNS surgeon. The presence of a general trauma surgeon is critical to the implementation of the system. An attending general trauma surgeon is typically present in most hospitals at all times and is capable of airway management, specifically emergency surgical airway (cricothyroidotomy). At our institution, during the day, the OHNS service has a dedicated faculty present in the hospital for difficult airway calls. However, during the night and on weekends, only the OHNS junior resident is in the hospital while the OHNS attending and chief resident are both on home calls. Should a DART occur during those times, the general trauma surgeon acts as the surgical attending physician supervising the OHNS junior resident during difficult airway cases until the OHNS attending surgeon arrives. The system of general trauma surgeon coverage practiced at the study institution could easily be translatable to other hospitals where OHNS is on home call. Such a multidisciplinary airway team model has been successful, in part, because of the regular multidisciplinary difficult airway course in which residents and attendings from respective departments participate.³⁰

Limitations

This study has limitations that are primarily related to the documentation issues in the pre-DART cohort. There is a possibility that the actual number of patients who required intubation in the pre-DART cohort is larger than analyzed, because, prior to 2008, a large proportion of medical documentation, including notes from consulting services such as Otolaryngology were placed in the paper form and may not have been formally incorporated into the hospital electronic medical records system. Similarly, airway interventions performed by anesthesiologists alone prior to 2008 may be underestimated for the same reason. A large number of coding errors for angioedema for the pre-DART cohort is also likely suggestive of a discrepancy between the written and electronic form of the hospital medical records. Such documentation challenges among the pre-DART cohort prevented any objective comparisons regarding the actual severity of oropharyngeal angioedema between the two cohorts.

Conclusion

Angioedema involving the laryngeal structures was a strong predictor of airway interventions among all patients in our study. DART had sufficient time to perform a fiberoptic airway evaluation prior to establishing a plan of care as a result of shorter response time and better access to equipment. Awake transnasal fiberoptic-guided intubation is used more commonly as the first choice of airway securement techniques. The number of attempts taken to secure an airway was fewer with DART. A multidisciplinary, standardized approach is recommended for safe and effective management of oropharyngeal angioedema.

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Figure 1:
This figure portrays a scenario where a patient is being intubated transnasally using fiberoptic laryngoscopy in the operating room.

Figure 2:

This figure displays a flowchart outlining how the number of angioedema cases were identified and categorized into 3 cohorts.

Figure 3:

This figure displays a flowchart showing the number of patients who were consulted for Otolaryngology-Head and Neck Surgeons, number of patients whose airways were evaluated, and the number of patients who received medications alone versus medications and intubation for interventions.

Figure 4:

This figure displays the techniques used to establish an airway for each attempt for each cohort.

Figure 5:

This figure displays the various views of a DART cart

Table 1:**Patient Characteristics**

Characteristics		Pre DART n = 36	Post-DART n = 27	p value
Age		54.5 ± 13.9	49.9 ± 15.0	0.21
Sex	Women	17 (47.2)	19 (70.4)	0.07
	Men	19 (52.8)	8 (29.6)	
Location of airway call	Floor	3 (8.3)	5 (18.5)	0.21
	Emergency Department	28 (77.8)	15 (55.6)	
	Intensive Care Unit	5 (13.9)	7 (25.9)	
Etiology	Angiotensin Converting Enzyme Inhibitor	21 (58.3)	7 (25.9)	0.003
	Other Medications	3 (8.3)	9 (33.3)	
	Hereditary	7 (19.4)	1 (3.7)	
	Idiopathic	4 (11.1)	8 (29.6)	
	Food	1 (2.8)	2 (7.4)	
Number of anatomical sites involved	1	19 (52.8)	17 (63.0)	0.42
	2	16 (44.4)	9 (33.3)	
	3	1 (2.8)	0	
	4	0	1 (3.7)	
Site Involvement	Lips	12 (33.3)	13 (48.1)	0.23
	Anterior tongue	10 (27.8)	13 (48.1)	0.10
	Floor of the mouth	4 (11.1)	0	0.10
	Soft palate	3 (8.3)	0	0.12
	Base of the tongue	3 (8.3)	3 (11.1)	0.71
	Larynx	8 (22.2)	7 (25.9)	0.73
	Pharynx	13 (36.1)	4 (14.8)	0.06

DART: Difficult Airway Response Team

All data presented in frequencies (percentages) except for variable age, which is presented as mean ± standard deviation.

Table 2:**Intervention Characteristics**

Intervention Characteristics		Pre DART (n = 36)	Post-DART (n = 27)	P value
Medications	Steroids	30 (83.3)	24 (89.0)	0.53
	Histamine 1 Blockers	26 (72.2)	23 (85.2)	0.20
	Histamine 2 Blockers	23 (63.9)	24 (88.9)	0.02
	Epinephrine	5 (14.0)	9 (33.3)	0.07
		(n = 4)	(n = 25)	
Time to respond in minutes		89.2	3.36	<0.01
		(n = 14)	(n = 18)	
Location of Airway Securement	Floor	1 (7.1)	1 (5.6)	0.12
	Emergency Room	2 (14.3)	2 (11.1)	
	Intensive Care Unit	0	6 (33.3)	
	Operating Room	11 (78.6)	9 (50)	
		(n = 14)	(n = 18)	
Service that finally established airway	Anesthesiology	4 (28.6)	6 (33.3)	0.51
	OHNS	9 (64.3)	12 (66.7)	
	Emergency Medicine	1 (7.1)	0	

DART: Difficult Airway Response Team

OHNS: Otolaryngology Head and Neck Surgery

Results are presented in frequency (Percentages)