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Title Examination of Patterns in Intubation by an Emergency Airway Team at a Large Academic Center: Higher Frequency During Daytime Hours

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Abstract

Background:

Emergency airway management represents an event with high acuity but unpredictable frequency, and therefore presents a challenge for adequate staffing. Given circadian and seasonal variations we hypothesized that the majority of emergent airway events happen after normal working hours and during the winter months.

Methods:

A retrospective analysis of 1,482 intubations performed by an emergency airway team over a three-year period. The data were obtained from hospitalized patients who required emergency airway management in a large academic medical center. A database of emergency airway consultations was analyzed for intubation time and date information, as well as geographic location within the hospital.

Results:

A greater percentage of emergency intubations occurred during day shift hours (7AM – 7PM) as opposed to night shift, 57% and 43%, respectively ($p<0.01$). The monthly frequency of intubations was not uniformly distributed across the year ($p<0.01$). The greatest percentage of intubations was performed in February (10.9%), with the lowest being recorded in August (4.7%).

Conclusions:

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Emergency airway service utilization is highest during daytime hours, with seasonal variations comprised of higher consults in the winter and lower consults in the summer.

Keywords: intubation; airway management; resuscitation; personnel staffing and scheduling

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1. Introduction

The immediate availability of an in-hospital airway consult service is a cornerstone of providing safe care for patients who require emergent airway management. Need for emergency airway support is a critical patient event, with potentially devastating consequences if the need is not addressed immediately. High acuity patient events with unpredictable frequency – such as emergency airway management – present challenges for allocating staffing and other resources.

Many investigators have studied the optimization of resource utilization in the setting of uncommon or unpredictable events. Examples include more common scenarios such as predicting trauma admissions based on seasonal and weather data[1] – to more hypothetical events, such as assessing readiness for managing mass casualty following attack with weapons of mass destruction.[2] Prediction of staffing patterns remains important, as staffing strategies have been shown to have an impact on patient morbidity and mortality.[3] With a particular focus on the management of emergency airway support, researchers have shown that adequate staffing exerts a limiting effect on the adverse impact of emergency airway events.[4, 5] However, there are no papers reporting the frequencies of such events; clarifying this distribution may help administrators match resources to needs.

Circadian variation in the frequency of medical emergencies has been reported.[6-9] We therefore hypothesized that the majority of airway emergencies would follow this pattern with the greatest number of airway consults occurring prior to the start of a standard work day, particularly during late night and early morning hours. Given the

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usual reduction in resources during such hours, an increase in emergency airway events would have potential implications for staffing adequacy.

Additionally, we examined seasonal variation in airway consults. Since the frequency of respiratory diseases increases during the winter months,[10, 11] we hypothesized that there would be a higher need for emergency airway management during this time period.

To test our hypotheses, we utilized a database of 1,482 intubations performed over a three-year period at a large academic medical center. The data were analyzed for temporal differences in frequency of emergent intubations.

2. Materials and Methods

The study was approved by the hospital's Institutional Review Board. From September 2007 through June 2010, data from emergent and urgent intubations were collected at a large, academic medical center – the Massachusetts General Hospital (MGH) in Boston, MA, USA.

MGH is a 900-bed, university-affiliated teaching hospital. It serves as a tertiary and quaternary referral center, a level-one trauma center, and a community hospital for the city of Boston, Massachusetts and nearby suburbs. Each year, there are approximately 1.5 million patient visits and 45,000 admissions. During the data collection period, there were eight adult intensive care units, which could accommodate a total of 130 patients.

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At MGH, the "emergency airway team" is a consultative service based in the surgical intensive care unit (SICU). It is comprised of an anesthesia resident rotating in the SICU, a critical care fellow, a staff intensivist, and a respiratory therapist.

Emergency airway consultations may result in intubation or in recommendations to the primary team to help otherwise optimize a patient with respiratory compromise. Only airway consultations that resulted in endotracheal intubation were included in these analyses. For the purposes of discussion, these events will be referred to as "intubations."

In the emergency ward (EW), the emergency medicine staff is primarily responsible for airway management; these such intubations are not captured in our analysis. However, the emergency airway team is occasionally consulted to the EW to perform intubations; these particular events are included in the dataset.

With the exceptions listed above, the emergency airway team is responsible for management of all emergency airway consultations in the adult hospital. Intubations performed in the SICU, where the emergency airway team is based, are included in the data.

Data were analyzed for variations in frequency across several time divisions. The first analysis involved dividing a 24-hour day into day-shift and night-shift periods, with day shift representing the hours of 7 AM to 7 PM. The second analysis divided a 24-hour day into six four-hour tranches to assess variations in consult frequency throughout the day. These tranches included: 3-7 AM, 7-11 AM, 11 AM – 3 PM, 3 PM – 7 PM, 7 PM – 11 PM, and 11 PM – 3 AM. Tranches were inclusive of the start time and exclusive of

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the end time. A third analysis studied month-to-month variations. For this purpose, data were normalized for months of available data.

To determine the influence of the number of patients in the hospital, we analyzed monthly variations in intubation frequency after normalizing the intubation data set against the monthly hospital census recorded during the data collection period.

In addition to temporal information, data were available regarding the indication for intubation. The categories available to describe the indication included: respiratory compromise, hemodynamic compromise, trauma/airway protection, and other. Categorical selection was not mutually exclusive.

Lastly, the method of endotracheal intubation (e.g. Miller blade, fiberoptic bronchoscope) and Cormack-Lehane laryngoscopic classification were recorded. As with indication, these categorizations were not mutually exclusive..

Statistical Analysis:

Data were compiled in Microsoft Excel and analyzed in Stata (Statacorp LP; College Station TX). Chi square analyses were performed to assess for variations across temporal categories. The null hypothesis was that the frequency of intubations was uniformly distributed across the time category of interest. A p-value less than 0.05 was considered to be significant.

3. Results

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The total number of intubations recorded was 1,482, representing approximately 1.5 intubations per day over the course of the study period. Data entries included date and time of the intubation as well as location within the hospital. Location data differentiated between intensive care unit (1,003 intubations) and ward patients (415 intubations), with 64 intubations lacking complete location information.

Data points which lacked information regarding date (9 intubations) and/or time (91 intubations) were excluded from the analysis (see Figure 1).

Time data were available for 1,391 intubations (94% of total). Of these, 799 (57%) occurred during the day shift (7AM – 7PM) and 592 (43%) occurred during night-shift hours ($p<0.01$). Comparing airway consult frequency across a divided day, most intubations occurred during 3 PM – 7 PM (n=286, 21% of total). The least number of intubations occurred during 11 PM – 3 AM (n=161, 12% of total). The frequency of intubations performed across the six 4-hour tranches was not uniformly distributed ($p<0.01$). Intubation frequency was homogeneously distributed across the three 4-hour tranches comprising the day shift ($p=0.06$). However, the frequency was not homogeneously distributed across the three tranches comprising the night shift ($p<0.01$). Figure 2 displays the frequency of intubations over the course of a 24-hour day.

We further analyzed monthly variations of emergent airway management. Date information was available for 1,473 intubations. The highest monthly average of intubations was recorded for February (n=57, 10.9% of total), with the fewest being in August (n=25, 4.7% of total). The monthly frequency of intubations was not uniformly distributed across the year ($p<0.01$).

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Lastly, we analyzed monthly intubation frequency after normalizing the data for the hospital's monthly census. Census data showed that the highest average number of hospital admissions occurred in the month of April (4,859), with the lowest occurring in February (4,330) and September (4,545). Figure 3 displays the frequency of intubations as distributed over the course of a 12-month year, normalized against admissions.

Of the intubations recorded, the indications for intubation were specified for the following categories: respiratory compromise (1,014 intubations); hemodynamic compromise (62 intubations); trauma/airway protection (226 intubations); and, other (158 intubations). Included in the previous totals are 172 intubations where multiple indications were specified. For 218 intubations, no indication was listed.

The method of endotracheal intubation was also available for most intubations. This included direct laryngoscopy using a MacIntosh blade (1,209 intubations) or Miller blade (93 intubations) and fiberoptic bronchoscopy (25 intubations). For 12 of the previously listed intubations, multiple modalities were specified. For 169 intubations, the method was not specified.

When direct laryngoscopy was performed, the Cormack-Lehane laryngoscopic classification was listed. These classifications were: Grade I (full view of glottis, 994 intubations); Grade II (partial view of glottis, 219 intubations); Grade III (view only of epiglottis, 98 intubations); Grade IV (no view of airway structures, 24 intubations). For 4 of the previously listed intubations, multiple Cormack-Lehane views were recorded. For 131 intubations, no view was recorded.

Intubations with a laryngoscopic grade of III and/or IV as well as intubations requiring a fiberoptic bronchoscope were assumed to be difficult. Taken as independent

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intubations, the total of probable difficult airways was 142, a 10.5% incidence of difficult airway. Timestamps were available for 131 of the 142 intubations with presumed difficult airway (92%). A non-significant majority of these difficult airways were encountered during the day-shift hours of 7 AM to 7 PM (n=75, 57.3%), with the remainder occurring during night-shift hours (n=56, 42.7%, *p=0.10*). These intubations were uniformly distributed throughout the course of the day (*p=0.29*, data represented in Figure 4).

4. Discussion

The principal finding of our study is that the majority of urgent and emergent intubations take place during the daytime hours of 7 AM – 7 PM. Furthermore, a majority of airway consultations for intubation occur during the winter and early spring months of January through March.

While the majority of intubations by emergency airway services take place during daytime hours, it is important to note that a clinically significant 43% of intubations take place during night shift hours. This fact stands in contrast to analyses of call patterns to medical emergency teams (rapid response teams) in which some studies have shown a higher frequency of calls during night shift hours.[12]

When looking at a 24-hour day with finer resolution, we show that the highest frequency of intubations occurs during the hours of 3 PM – 7 PM, with the lowest frequency occurring during 11 PM – 3 AM. It is impossible to determine from these data the explanation for such a drop in frequency overnight, although there is evidence to

support circadian variations in the frequency of medical emergencies.[6] An alternative possibility would be diurnal variations in the extent of attention and therapeutic interventions delivered to patients – perhaps as a calculated tradeoff to improve sleep quality and quantity[13, 14]. This phenomenon has been witnessed when studying calls to medical emergency teams,[15] and might imply that intubations that should have been performed overnight are instead delayed until daybreak. Additional study is warranted to determine if a significant number of early-morning airway consults are performed for patients with more severe respiratory distress, or if this cohort of patients suffer worse clinical outcomes.

We observed a drop in intubations during the summer months of July through September, with an increase during the winter and spring months of January through May. This may relate to the increased incidence of respiratory illness witnessed during the winter and early spring months. It also correlates with an elevated hospital census during these months, although this increase alone does not account for the higher number of airway consults (Figure 3).

Additionally, the highest monthly frequency of emergency airway consults does not coincide with the introduction of new trainees, mitigating the consequences of any such so-called "July Effect"[16] on airway events.

Some narrow conclusions may be drawn about the incidence and frequency of difficult intubation encountered at the study institution. When using proxy indicators for airway difficulty, we showed a nearly 11% incidence – on the lower end of the reported range of 11-25% for out-of-operating room difficult intubations.[17-19] Our data displayed an even proportional distribution of these presumed difficult intubations across a 24-hour

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day; it is reassuring that this frequency did not increase during off-shift hours when resources are fewer.

Limitations to the study include the fact that this is a retrospective analysis. It is unknown whether similar patterns exist at other hospitals of different types (e.g. non-academic) and sizes. Additionally, the composition of the emergency airway team and its responsibilities may be significantly different at other institutions.

The database does not include outcomes data and therefore the study cannot address whether there is a seasonal or hourly variation in complications or difference of outcomes of emergent airway management. The database does not include airway consultations that did not result in intubation, and so resource utilization is not captured for "non-urgent" airway consultations which result in therapies such as non-invasive positive pressure ventilation.

Overall, these data show moderate variation in the frequency of emergency airway consults in the hospital – a relatively common event at 1.5 intubations per day at the 900-bed study institution. Our analysis shows that demand for emergency airway support drops during the evening hours, a fact that may indicate that nighttime airway consult resources do not need to be augmented above daytime levels. This recommendation would be tempered, however, if additional studies showed that a drop in overnight emergency airway consult frequency is explained by the delay of intubation that was clinically indicated earlier.

5. Conclusions

Need for emergency intubation is a common but unpredictable event. Frequency of intubations by emergency airway consult services is highest during day shift hours. There is a seasonal fluctuation comprised of higher consults in the winter and early spring months of January through March, with decreased frequency in the summer months of June through August.

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7. Titles and Legends of Figures

Figure 1. Dataset composition flowchart.

Data are shown for intubations included in hourly analysis only. Flowchart does not display distribution of intubations included in monthly analysis.

Figure 2. Intubation frequency by 4-hour tranche.

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A percentage of the daily total of intubations by the emergency airway team is displayed for each of six 4-hour tranches.

Figure 3. Intubation frequency by month as normalized to hospital census.
The number of intubations by the emergency airway team is displayed for each month and year, as a total per 4,700 admissions (the average monthly admissions during the study period). The trendline represents the monthly average intubations for all available data.

Figure 4. Difficult airway frequency by 4-hour tranche.
Presumed difficult intubations are displayed as a percentage of each tranche's total intubations. Cormack-Lehane classifications III and IV and use of fiberoptic bronchoscopy were used as proxies for airway difficulty.

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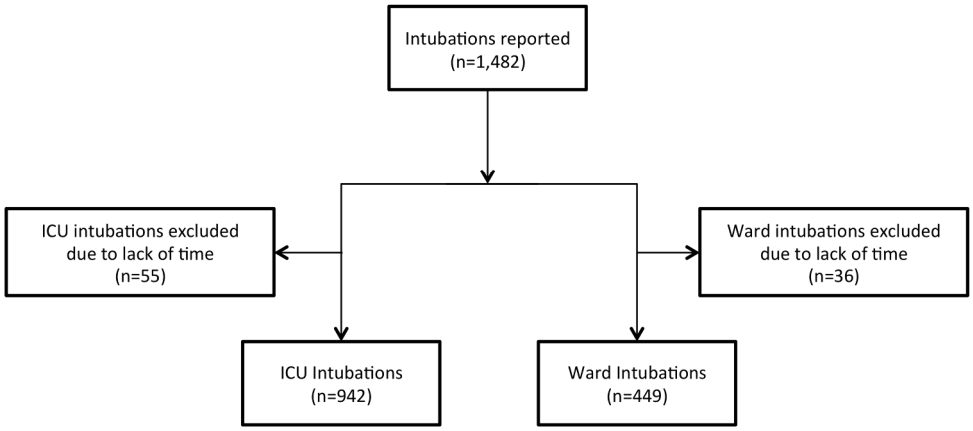

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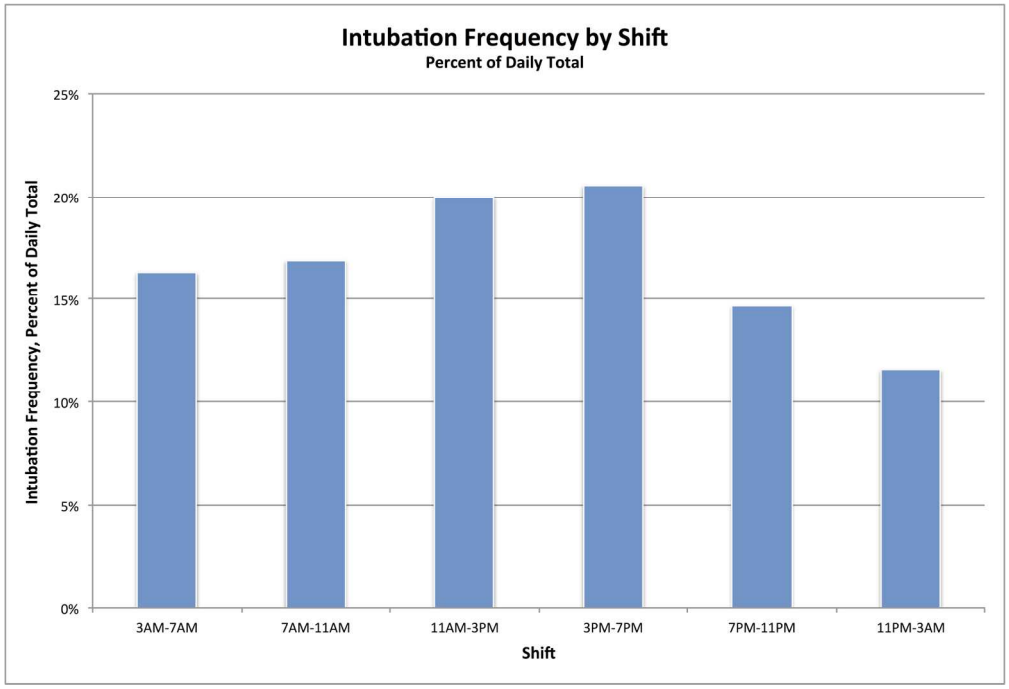

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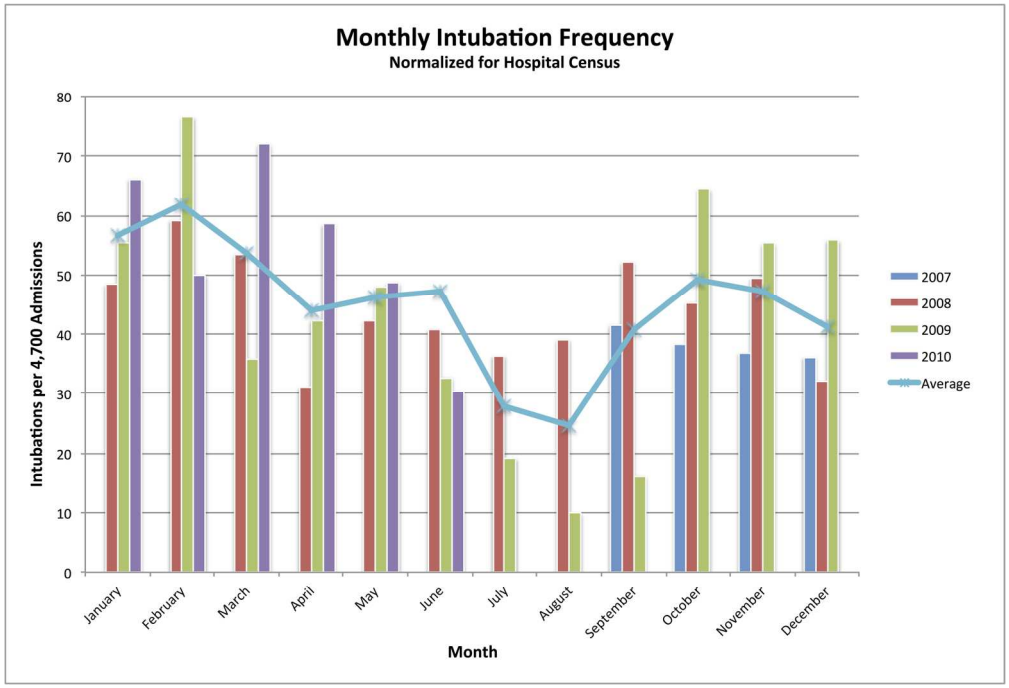

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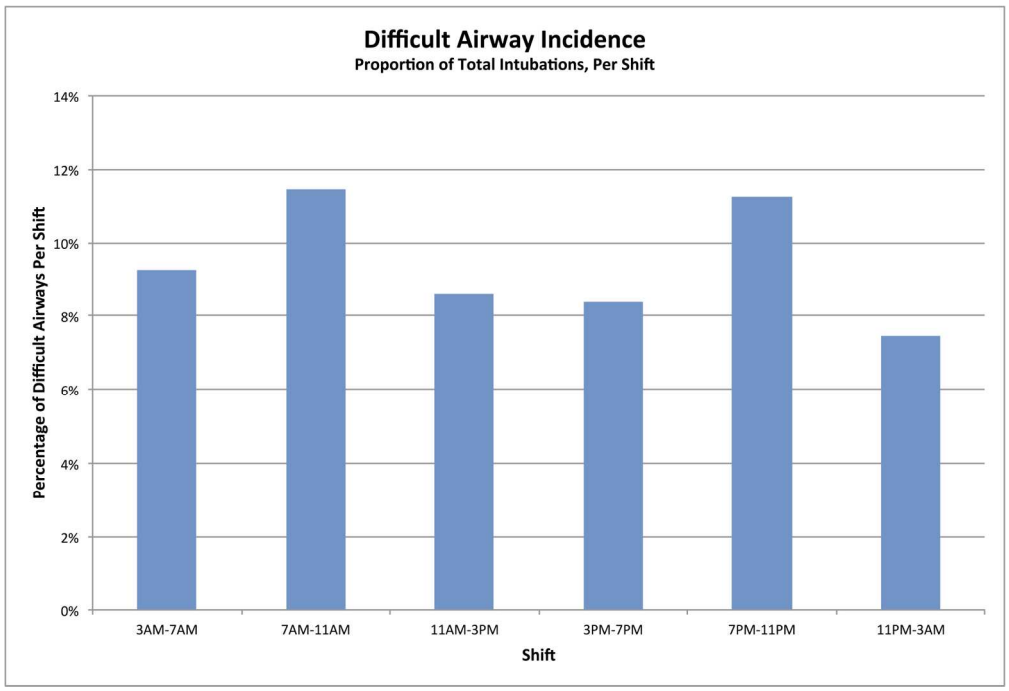

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