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The monthly operating cost of an institutional COVID-19 airway response team: A financial model and sensitivity analysis based on experience at an academic medical center

Alexander B. Stone [a,*], Michael C. Grant [b], Serena S. Dasani [a], Luigino Nascimben [a]

[a] Brigham and Women's Hospital, Boston, MA, USA
[b] Johns Hopkins Hospital, Baltimore, MD, USA

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ABSTRACT

Background: Coronavirus disease 2019 (COVID-19) airway response teams concentrate equipment and expertise while minimizing the number of providers exposed to aerosol generating procedures. These airway teams were implemented in various hospitals around the world to respond to the acute increase of critical ill patients requiring ventilatory support. We created a financial model to estimate the costs for staffing and maintaining a dedicated COVID-19 airway response team based on the experience at an urban academic hospital in the Northeastern United States between March and June of 2020.

Methods: The institutional review board at Brigham and Women's Hospital approved this protocol and the requirement for informed consent was waived. The average reimbursement for 125 COVID-19 airway consultations was measured. Our team estimated the costs of consumable items for each airway based on previously published recommendations for equipment and personal protective equipment. A sensitivity analyses was performed for variable numbers of monthly airway consults and different staffing patterns based on a literature review of available COVID-19 airway team structures.

Results: Based on the average reimbursements and estimates of the consumable costs, each airway procedure represented a net loss of $34 to the institution. The overall estimated cost of staffing a dedicated airway team was between $109,472 and $204,575 per month.

Conclusions: Development and implementation of a dedicated COVID-19 airway response teams represents a significant institutional expense. Institutions should establish necessary cost sharing, consider volume and team structure, and identify reimbursement opportunities that mitigate the necessary expense associated with airway response programs.

1. Introduction

The coronavirus disease (COVID-19) pandemic caused a surge of critically ill patients in the northeastern region of the United States between March and June of 2020. With that surge came an overwhelming number of patients with critical illness, severe viral pneumonitis, concomitant pneumonia, and hypoxic respiratory failure. Anesthesiologists were at the forefront of the response, staffing intensive care units (ICU), acting as respiratory therapists and augmenting the pool of emergency bedside personnel. In addition, anesthesiologists were called upon to develop and implement a dedicated COVID-19 airway response program. These COVID-19 airway response programs were designed to allow health care systems to concentrate the most technically skilled staff, optimize the use of limited personal protective equipment (PPE), supplies and medications and minimize the number of providers exposed to high risk aerosol generating procedures.

The airway response team represented a significant change from the prior emergency airway response model at the Brigham and Women's Hospital. Prior to the COVID-19 pandemic, the emergency airway response was staffed by a team comprised of main operating room anesthesia personnel, including a senior resident and faculty anesthesiologist. Similar to other institutions, this required the team to divide their attention between ongoing clinical responsibilities and an airway response pager. Due to the volume, acuity and resources of the COVID-

* Corresponding author at: Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115, USA.
E-mail address: abstone@partners.org (A.B. Stone).

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19 critical patient surge, an alternative model was adopted. This dedicated airway response team, removed from other clinical obligations, now consisted of a full-time (24 h per day and 7 days per week) dedicated faculty anesthesiologist, certified registered nurse anesthetist (CRNA) and anesthesia technician.

In order to better evaluate the value of such a program, our group sought to develop a financial model to articulate the costs for staffing and maintaining a dedicated COVID-19 airway response team. Our model and sensitivity analysis were based on our experience in Boston as well as published reports from other hospitals in the United States. The model can thus be adjusted to suit local contexts and can help guide hospital level decision making with regards to resource allocation and preparedness for similar critical care patients surges in the future.

2. Methods

2.1. Financial model development

The study protocol was approved by the Brigham and Women's Hospital institutional review board (IRB) (protocol number 2020P002963) and the requirement for informed consent was waived. The CHEERS guideline for economic evaluations was used for this study (supplement file 1). Using methods similar to published financial analysis of other quality improvement programs, a model was designed to analyze the financial impact of implementing a dedicated COVID-19 airway response team at a single institution.[1,2] The key variables that were considered were: (a) costs of airway equipment and medications; (b) estimated volume of airway procedures; (c) reimbursement associated with individual personnel and team structures. Estimates were based on available published data from the United States, as well as experience from the COVID-19 response at the Brigham and Women's Hospital. The primary objective was to project the monthly budget for operating and maintaining a dedicated COVID-19 airway program. Data were collected and analyzed using Excel (Microsoft Corporation, Redmond, WA).

2.2. Variables for the financial model

2.2.1. Equipment and medications

After review of the guidelines put forth for COVID airway responses published by the European Society of Anesthesiologists, the American Society of Anesthesiologists and the Difficult Airway Society,[3] we compiled a list of the necessary consumables utilized by airway teams for each intubation consultation. Costs were obtained for personal protective equipment (PPE; i.e., surgical masks, N95 respirator, face shield, gown, gloves and foot coverings), disposable video laryngoscope blades, medications (i.e., sedation, neuromuscular blockers, and intravenous vasoactive), as well as other materials such as suction catheters, oral airways, and bag-mask assemblies.[4] The cost of each item was estimated based on institutional records, public records, distributor websites and previously published values.[5,6] The exact costs of each item are the result of negotiations between suppliers and our group purchasing organization and an itemized costs of each item were deemed not appropriate for publication by our hospital administration.

2.2.2. Number of consultations

We performed a sensitivity analysis based upon three potential scenarios, including 30, 50, and 100 intubation consultations per month. The numbers chosen for the sensitivity analysis were based on pre-pandemic historical data that our airway team responds to approximately 40 to 50 airway consultations per month. Our model represents the budget associated with a single airway team.

2.2.3. Personnel

We performed a literature review to identify published examples of COVID-19 airway team structures (Table 3). Based upon those results, our model considered the costs associated with three different team structures. These include: (1) *Advanced Team*: two faculty anesthesiologists and an anesthesia technician; (2) *Brigham Team:* one faculty anesthesiologist, one CRNA, and an anesthesia technician; (3) *Basic Team*: faculty anesthesiologist and an anesthesia resident. We obtained average salary data for each position from the Bureau of Labor Statistics 2019,[7] and then calculated the cost of each position using: (a) average hourly wages normalized; and (b) average yearly salary, each normalized by month.

2.2.4. Capital expenditures

To simplify the model and be as conservative as possible, we did not incorporate capital expenditures such as dedicated airway equipment (i.e., video laryngoscopes, dedicated carts, or powered air purifying units [PAPRs]). PAPRs use at our hospital was limited to personnel who did not pass mask fit tests with N95s. Potential in-service education costs, communication equipment or administrative support were not included based upon the assumption is that in time of crisis, hospitals would be required to repurpose available resources and support staff at their disposal.

2.2.5. Consultation reimbursement

The current procedural terminology (CPT) code 31,500 was applied as the billing code for each emergency airway consultation. The +22-billing modifier was not routinely used in our practice as it would delay reimbursements. This billing modifier is typically reserved for complex procedures but would require additional documentation and communication between the physicians and the payors, thus was not considered in our model. We queried our local administrative database to calculate the average actual reimbursement for the billing code 31,500 for the period between March 16th 2020 and June 30th 2020.

3. Results

3.1. Costs per airway and number of airway procedures performed per month

Table 1 estimates the average cost per airway consultation. We estimated that the disposable equipment costs were $225 dollars per airway. Medications brought into the room at the time of intubation would have to be wasted due to COVID contact precautions. Between March 16 and June 30, the average reimbursement for CPT code 31,500 was $188.46. The net expense to the institution for each airway

Table 1
Sensitivity analysis of revenue per airway by number of monthly cases. This table summarizes the net revenue per airway before considering personnel and staffing costs. A sensitivity analysis was performed for a range of cases per month. Numbers in green represents revue for the anesthesia department and numbers displayed in red represent costs.

	Cost per case estimate USD	30 cases per month	50 cases per month	100 cases per month
Personal protective equipment	$50	$1500	$2500	$5000
Disposable video laryngoscope equipment	$45	$1350	$2250	$4500
Medications	$110	$3300	$5500	$11,000
Other consumables	$20	$600	$1000	$2000
Total Consumable costs	$225	$6750	$11,250	$22,500
Reimbursement (CPT 31,500)	$188	$5654	$9424	$18,847
Net Cost to Department	$37	$1096	$1827	$3653

*Net revenue in green text and net losses are in red text.

consultation was therefore approximately $34. Between March 16th and June 30th our airway teams responded to 125 airways for an average of 35.7 airways per month, which resulted in a net expense between $1096 and $3653 depending on the number of procedures performed. This does not account for airway consults where no endotracheal tube was placed as the number of airways was calculated from the number of times the CPT code 31,500 was billed.

3.2. Personnel costs

Based upon the United States Bureau of Labor statistics 2019 survey, the hourly wage for each position was multiplied by 720 h to account for around the clock coverage. Salary estimates were calculated and normalized into monthly allotments. Regardless of the model, estimated cost of staffing the airway team were similar (Table 2).

3.3. Varying team structures

After review of the literature and based upon our own experience (Table 3), we modified the analysis based upon three different team structures (i.e., Advanced, Brigham and Basic). Overall cost varied according to team structure and number of airways performed (Table 4), with totals ranging from $111,695 to $204,575 per month based upon hourly wages and $109,472 and $197,129 per month based upon estimated yearly salary. Supplemental file 2 provides a calculator tool which allows a user to estimate the monthly cost of establishing a dedicated airway program.

4. Discussion

Many anesthesiologists have served on the front lines of the COVID-19 pandemic by applying their airway management expertise for the benefit of critically ill patients. Intubations of COVID-19 patients are considered high risk given the potential for both complication to the patient and risk of transmission to the provider.[8] It is recommended that the team member with the most airway management experience perform the intubation for COVID-19 patients.[4] Establishing dedicated airway teams helps to concentrate limited resources and expertise to ensure intubation procedures are as safe as possible for all involved. Donning and doffing PPE safely takes time and experience and communication can be limited when providers are wearing appropriate PPE. We calculated the costs of staffing a COIVD-19 airway team that had no other clinical duties, consistent with our practice between March and June of 2020. Our analysis shows that establishing such a team comes at a considerable financial cost to the institution. We found that based on consumable items alone, each airway represents a net expense to the overall program. When staffing costs are considered, losses are magnified and may exceed upwards of $108,472 to $204,525 per month, depending on the both the procedural burden and the established team structure.

Our model represents a conservative analysis, whereby existing communications and administrative staff infrastructure are redeployed to support the airway program. We have based the analysis on national average salaries and national average reimbursement rates, which may not fully reflect all markets. The hourly rate incorporated for a faculty anesthesiologist may underestimate figures in other practice environments or locations, particularly when accounting for overnight or weekend coverage. We used the average reimbursement for CPT code 31,500 at our hospital for this model, which may be an overestimate of reimbursements in areas with different payor mixes. The average reimbursement for CPT code 31,500 for patients with Medicare or Medicaid is closer to $140.[9] Lastly, we have specifically chosen not to include capital expenses associated with dedicated airway equipment, carts or instruments. Despite this, our cost estimates exceed those that were previously published involving the implementation of a non-COVID-19 difficult airway program at Johns Hopkins.[5] They estimate a yearly operating expense of $543,633 (approximately $45,302 per month). Although their model included capital expenditures for new equipment, they did not factor in around the clock in-house faculty level staffing dedicated to the airway program, which almost certainly

Table 3
Published team structures for designated COVID-19 airway teams. The various published team structures for COVID-19 airway response teams. Most articles recommend multiple healthcare providers.

Author/Group	Location	Team structure
Miller et al.[14]	New York City, USA	1 attending and 2 residents
European Society of Anesthesia[3]	Europe	2 attendings
Lee et al.[15]	Toronto, Canada	1 attending + 1 airway assistant
Cook et al.[16]	Europe	Does not specify
Thiruvenkatarajan[17]	International	1 Airway operator + 1 airway assistant + 2nd airway operator (optional)
Brigham and Women's	Boston, USA	1 attending+1 CRNA+ 1 Anesthesia Tech

Table 4
The sensitivity analysis different COVID-19 airway team structures and cases rates. This table summarizes the monthly costs for three different COVID-19 staffing patterns *Advanced Team*: two faculty anesthesiologists and an anesthesia technician; *Brigham Team:* one faculty anesthesiologist, one CRNA, and an anesthesia technician; *Basic Team*: faculty anesthesiologist and an anesthesia resident. Numbers displayed in red represent net costs to the anesthesia department. .

	Hourly wages			
# Monthly Airways	0	30	50	100
Advanced	$198,000.00	$199,095.90	$200,922.40	$204,575.40
Brigham	$169,200.00	$170,295.90	$172,122.40	$175,775.40
Basic	$111,600.00	$112,695.90	$114,522.40	$118,175.40
FTE				
# Monthly Airways	0	30	50	100
Advanced	$190,554.33	$191,650.23	$193,476.73	$197,129.73
Brigham	$163,657.67	$164,753.57	$166,580.07	$170,233.07
Basic	$108,376.67	$109,472.57	$111,299.07	$114,952.07

Estimate of the monthly costs of staffing and maintaining a dedicated COVID airway response team. Net losses are in red text.

Table 2
Staffing costs for around the clock coverage of an airway team. This table summarizes the estimated monthly costs for staffing the airway team. The first method used an estimate of the hourly salary for each position multiplied by 720 h. The second method used estimates of yearly salary or 1 full time equivalent (FTE) per position. To calculate the cost of staffing around the clock each FTE was multiplied by 4. .

	Hourly salary (USD)	720 h	Yearly Salary (1FTE)	Monthly Salary	x4 FTE per month
Faculty Attending	$125.00	$90,000.00	$261,730.00	$21,810.83	$87,243.33
CRNA	$85.00	$61,200.00	$181,040.00	$15,086.67	$60,346.67
Resident	$30.00	$21,600.00	$63,400.00	$5283.33	$21,133.33
Anesthesia Tech	$25.00	$18,000.00	$48,203.00	$4016.92	$16,067.67

contributed to increased expense in our model.

This analysis is not without limitations. Our experience was based on a large academic teaching hospital with a large anesthesia department and substantial resources. Our airway team had been established within the hospital prior to COVID-19 and, therefore, the existing infrastructure, including dedicated equipment, was already in place. Anesthesiology department staffing during a pandemic is complex and our model makes several assumptions regarding team structure and reimbursement that may not fully reflect local rates or practice patterns. Our model also assumes that staff are solely dedicated to airway responsibilities, which although recommended, may not be required when hospitals are not experiencing a significant surge in critically ill patients. Although not represented in this model, airway teams may also serve as consultants for other procedures (i.e., obtaining arterial and central venous access), a service and reimbursement that is likely to alter the result of our model.

The COVID-19 pandemic led to a significant decrease in the elective surgical procedures throughout the United States. Some anesthesia staff were redeployed to care for ICU patients, and a number of staff member had to quarantine following COIVD-19 exposures and a few elected to take a temporary leave of absence. However, there was a surplus of salaried anesthesiologists and CRNAs when the number of surgical procedures dropped precipitously during the height of the pandemic which represents a sunk cost. At our large academic institution, the operating room staffing model was changed to designated shifts and overtime pay was eliminated to mitigate the effects of the sunk staffing costs and prevented the need for furloughing staff. One of the limitations of considering the personnel costs in our model is that anesthesia services staffing is fairly inflexible on a month-to-month time scale. When hospitals faced high volumes of patients affected with COVID-19, it is possible that larger institutions and anesthesia groups had more anesthesia providers than necessary for the surgical volume at that time. Thus, staffing an airway team may not represent a marginal cost in terms of stacffing in the short term but rather a mechanism reallocating resources. In the longer term, or if an anesthesia group relies on a flexible staffing model with locum tenens providers, we would expect that anesthesia staffing would be adjusted for surgical volume and that staffing an airway team would represent a substantial cost in the short term.

During the pandemic, at our institution, the CPT billing modifier +22 was not used because it would require additional documentation, which was thought would lead to increase administrative burden and delayed reimbursements. It is important to note that this billing modifier increases the amount providers will be reimbursed from CMS by approximately 20%. By our estimates, this could represent a meaningful difference that would transform each airway event from a revenue loss to a net profit gain. Practices should consider routinely using the billing modifier +22 for COVID-19 airways when appropriate as a way of capturing additional billable revenue.

The prevalence and amount of direct payments from hospitals to anesthesia groups in the United States has been increasing for both private practice[10] and academic anesthesia groups in recent years.[11] These direct payments subsidize care provided by anesthesia departments that are not fully reimbursed by payors such as anesthesia care for underserved populations and overnight call team coverage. Staffing of emergency airway teams to meet the needs of the COVID-19 pandemic represents another area where direct payments may be necessary to keep anesthesia groups financially viable.

The COVID-19 pandemic has shifted the financial landscape of medicine in general and anesthesiology in particular throughout the country. The majority of the available literature has focused on loss of revenue from delaying or canceling elective procedures.[12,13] To our knowledge, ours is the first model to focus on the expenses associated with one primary aspect of an anesthesiology department's response to the COVID-19 crisis. Our analysis suggests that reimbursement for emergency airways alone is insufficient to cover the expense to the institution. This model may serve as an outline to guide groups in preparing for similar dedicated team-based responses in the future. Our analysis highlights the importance of institutional foresight in considering thoughtful strategies to remain financially viable in order to permit safe and effective provision of life-saving interventions.

Author's contribution

Alexander Stone: This author helped with conception and design of the study; data acquisition and analysis; interpretation of data for the work; manuscript preparation, and final approval of the manuscript

Michael Grant: This author helped with interpretation of data for the work; manuscript preparation, and final approval of the manuscript

Serena Dasani: This author helped with designing the study; interpretation of data for the work; manuscript preparation, and final approval of the manuscript

Luigino Nascimben: This author helped with conception and design of the study; data acquisition and analysis; interpretation of data for the work; manuscript preparation, and final approval of the manuscript

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.pcorm.2021.100168.

References

1 Stone AB, Grant MC, Pio Roda C, et al. Implementation costs of an enhanced recovery after surgery program in the United States: a financial model and sensitivity analysis based on experiences at a quaternary academic medical center. *J Am Coll Surg*. 2016. https://doi.org/10.1016/j.jamcollsurg.2015.11.021. Published online January 7.

2 Lord RK, Mayhew CR, Korupolu R, et al. ICU early physical rehabilitation programs: financial modeling of cost savings. *Crit Care Med*. 2013;41(3):717–724. https://doi.org/10.1097/CCM.0b013e3182711de2.

3 COVID-19 Airway Managment. https://www.esahq.org/uploads/2020/04/safe-airway-society-covid-19.pdf.

4 Wax RS, Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. *Can J Anesth/J Can Anesth*. 2020;67(5):568–576. https://doi.org/10.1007/s12630-020-01591-x.

5 Mark LJ, Herzer KR, Cover R, et al. Difficult airway response team: a novel quality improvement program for managing hospital-wide airway emergencies. *Anesth Analg*. 2015;121(1):127–139. https://doi.org/10.1213/ANE.0000000000000691.

6 Atcheson CLH, Spivack J, Williams R, Bryson EO. Preventable drug waste among anesthesia providers: opportunities for efficiency. *J Clin Anesth*. 2016;30:24–32. https://doi.org/10.1016/j.jclinane.2015.12.005.

7 U.S. *Bureau of Labor Statistics*; 2019. Published online https://www.bls.gov/oes/current/oes291211.htm.

8 Weissman DN, de Perio MA, Radonovich LJ. COVID-19 and risks posed to personnel during endotracheal intubation. *JAMA*. 2020;323(20):2027. https://doi.org/10.1001/jama.2020.6627.

9 Joffe AM. Use your SMARTs (some kind of multidisciplinary airway response team) for emergent airway management outside the operating room. *Anesth Analg*. 2015;121(1):11–13. https://doi.org/10.1213/ANE.0000000000000723.

10 O'Connell C, Dexter F, Mauler DJ, Sun EC. Trends in direct hospital payments to anesthesia groups: a retrospective cohort study of nonacademic hospitals in California. *Anesthesiology*. 2019;131(3):534–542. https://doi.org/10.1097/ALN.0000000000002819.

11 Kheterpal S, Tremper KK, Shanks A, Morris M. Workforce and finances of the United States anesthesiology training programs: 2009–2010. *Anesth Analg*. 2011;112(6):1480–1486. https://doi.org/10.1213/ANE.0b013e3182135a3a.

12 Billig JI, Lan W-C, Chung KC, Kuo C-F, Sears ED. The increasing financial burden of outpatient elective surgery for the privately insured. *Ann Surg*. 2020. https://doi.org/10.1097/SLA.0000000000004201. Published online July 24.

13 Fu SJ, George EL, Maggio PM, Hawn M, Nazerali R. The consequences of delaying elective surgery: surgical perspective. *Ann Surg*. 2020. https://doi.org/10.1097/SLA.0000000000003998. Published online April 29.
14 Miller L, Luković E, Wagener G. Guiding airway management and personal protective equipment for COVID-19 intubation teams. *Br J Anaesth*. 2020;125(3):e288–e290. https://doi.org/10.1016/j.bja.2020.06.001.
15 Lee DW, Ma M, Parotto M, Wąsowicz M. Intubation outside of the operating room: new challenges and opportunities in COVID-19 era. *Curr Opin Anaesthesiol*. 2020;33(4):608–611. https://doi.org/10.1097/ACO.0000000000000892.
16 Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID -19: guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists. *Anaesthesia*. 2020;75(6):785–799. https://doi.org/10.1111/anae.15054.
17 Thiruvenkatarajan V, Wong DT, Kothandan H, et al. Airway management in the operating room and interventional suites in known or suspected COVID-19 adult patients: a practical review. *Anesth Analg*. 2020;131(3):677–689. https://doi.org/10.1213/ANE.0000000000005043.