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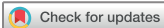
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Variation in Intensive Care Unit Intubation Practices in Pulmonary Critical Care Medicine Fellowship

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ABSTRACT

Background: Endotracheal intubation in the intensive care unit (ICU) is a high-risk procedure. Competence in endotracheal intubation is a requirement for Pulmonary and Critical Care Medicine (PCCM) training programs, but fellow experience as the primary operator in intubating ICU patients has not been described on a large scale.

Objective: We hypothesized that significant variation surrounding endotracheal intubation practices in medical ICUs exists in U.S. PCCM training programs.

Methods: We administered a survey to a convenience sample of U.S. PCCM fellows to elicit typical intubation practices in the medical ICU.

Results: Eighty-nine discrete U.S. PCCM and Internal Medicine Critical Care Medicine training programs (77% response rate) were represented. At 43% of programs, the PCCM fellow was “always or almost always” designated the primary operator for intubation of a medical ICU patient, whereas at 21% of programs, the PCCM fellow was “rarely or never” the primary operator responsible for intubating in the ICU. Factors influencing this variation included time of day, hospital policies, attending skill or preference, ICU census and acuity, and patient factors. There was an association between location of the training program, but not program size, and whether the PCCM fellow was the primary operator.

Conclusion: There is significant variation in whether PCCM fellows are the primary operators to intubate medical ICU patients during training. Further work should explore how this variation affects fellow career development and competence in intubation.

Keywords:

intubation; intratracheal; education; medical

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Accreditation Council for Graduate Medical Education requirements for Pulmonary and Critical Care Medicine (PCCM) training programs specify that graduates must achieve competence in airway management, including endotracheal intubation (1). However, the Accreditation Council for Graduate Medical Education does not describe what methods are needed to achieve competence, and thus, there are differences in experiential training between programs (2, 3).

Endotracheal intubation is one of multiple procedures that are “shared” with other specialties outside of PCCM (e.g., thoracentesis, chest tube insertion, central venous catheter insertion, pulmonary artery catheter placement, percutaneous tracheostomy, and bronchoscopy). In some cases, institutional requirements or tradition may have delineated pathways for “ownership” of these procedures (i.e., which service line is responsible for which procedure). For instance, studies of paracentesis (4) and thoracentesis (5) have shown variable institutional practice patterns regarding procedure cost or complication rates. However, the extent of variation in fellows’ experiences of institutional practices surrounding endotracheal intubation in the intensive care unit (ICU) has not been well described, and it is unknown how such institutional variation affects PCCM fellowship training. At some centers, emergency medicine training programs share airway management with anesthesiology training

programs, and some institutions have described protocols for alternate-day specialty “ownership” of endotracheal intubation, with comparable clinical outcomes (6).

Endotracheal intubation in the ICU is a high-risk procedure and differs from intubation in the controlled environment of the operating room in that “the situation is uncontrolled, tools are suboptimal and the patient, by definition, is critically ill” (7). Complications have been reported to result from nearly 30% of ICU intubations and include severe hypoxemia, cardiovascular collapse, and death (8, 9). One study of critical care residents in France showed failure and complication rates of 17.6% and 17.5%, respectively, when endotracheal intubation in the ICU is performed by trainees, with higher risk of failure when the procedure was urgent or the trainee less experienced (10). Notably, residents in French intensive care training programs may come from anesthesiology *or* internal medicine training, among other pathways. In the United States, however, PCCM fellows have nearly exclusively trained in internal medicine and Internal Medicine Critical Care Medicine (IM-CCM) fellows in mostly internal medicine.

How do U.S. PCCM and IM-CCM fellowship programs train fellows in airway management? Individual programs have described curricula for training PCCM fellows in the context of studies of first-pass success or comparison of different laryngoscopy techniques (11, 12). A 2012

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survey study of PCCM and IM-CCM program directors indicated that 58% of programs had a dedicated airway management rotation that most often occurred during the first year of training (2). Although Joffe and colleagues reported information about the types of equipment trainees were exposed to (supraglottic airways, video laryngoscope, etc.), they did not study where airway management experience occurred outside of the dedicated airway rotation. A 2014 survey of program directors representing 56 discrete PCCM and IM-CCM programs identified some variation in the percentage of all intubations in the program's primary ICU performed by a fellow (3). This survey was limited by low response rate, and the authors acknowledged that fellows rather than program directors may have provided different information.

We hypothesized that fellows experience a range of institutional practices surrounding endotracheal intubation *outside* of the context of a structured airway rotation. Specifically, we hypothesized that there was variation in whether PCCM and IM-CCM fellows were the primary operator to intubate a patient in the medical ICU. We sought to describe this institutional variation from the fellow perspective before further study of the effects of ICU intubation experience on PCCM fellow training and career development.

METHODS

We developed a survey to describe variation in the medical ICU (MICU) intubating practices of U.S. PCCM and IM-CCM fellowships. The survey was collaboratively developed by all authors; cognitive interviewing was performed by three authors (A.K.B., W.B., W.G.C.) at three separate institutions with fellows who

would not be eligible to complete the final survey, and survey items were revised and clarified after this process.

The survey contained nine items. Respondents were asked how often the PCCM or IM-CCM fellow in the MICU was the primary operator (worded as “first call”) to intubate a MICU patient (Likert scale ranging from 1 to 5 with 1 being always or almost always and 5 being never). If respondents answered “sometimes” to this question, they were prompted to select factors that influenced whether the PCCM fellow was the primary operator. They were also asked how often the anesthesiology team was the primary operator for MICU intubations. Demographic information included year in training, name of institution, and number of fellows in the training program. Respondents were asked to indicate if they would want to be contacted for a follow-up qualitative study and to provide their email address. Confidentiality of all information was guaranteed, and email addresses were not linked to other responses.

To achieve a representative sample of U.S. PCCM and IM-CCM training programs, we selected as our respondents the attendees of the American Thoracic Society 2019 Fellows Track Symposium (FTS). The FTS is an annual, 2-day educational session for current PCCM and IM-CCM fellows. It is designed to complement the scientific sessions at the American Thoracic Society International Conference with an emphasis on relevant content for fellowship trainees (13). FTS Leadership approved the survey's administration. The Institutional Review Board at Oregon Health and Science University provided oversight for this study, which was deemed exempt. The survey was distributed on paper to all

attendees on the first day of the FTS and collected by the authors the same day.

Descriptive statistics were used to characterize programs and respondents. Fisher's exact test was used to look for associations between whether the PCCM or IM-CCM fellow was the primary operator "always or almost always" or "most of the time" and both location and program size. For this analysis, size was used as a categorical variable of small (10 or fewer fellows), medium (11–17 fellows), or large (18 or more fellows). Fisher's exact test was performed with Stata Version 16.1 (StataCorp).

RESULTS

Demographics

There were 134 responses to the survey out of a potential 175 fellows registered for the FTS (77% response rate). Of these 134, 15 respondents did not identify their training program, and their results were excluded from analysis. There were 26 programs with more than one fellow in attendance (most had two fellows in attendance, although one had three).

Multiple responses from the same program were handled as follows: in 12 cases, responses to both main questions (how often is the PCCM fellow or anesthesiology team the "first call" to intubate) were identical. In 11 cases, responses to only one of the central questions were identical, with similar but not identical responses to the second question. In those cases, the answer further from the extreme was kept: for example, if one respondent indicated that the PCCM fellow was the primary operator "always" and another indicated "most of the time," the response "most of the time" was kept for final analysis. In three cases, the responses from two fellows

in the same program differed for both of the main questions, and data from those programs were discarded for the main analysis. Exclusion of unidentified programs and conflicting responses left 89 discrete programs with one complete response per program.

For our central question ("How often is the PCCM or IM-CCM fellow in the MICU the first call to intubate a MICU patient?"), a repeat analysis including all 134 responses was performed, and results were similar to the results obtained with the 89 discrete programs. Further analyses reported here use the 89 programs with complete responses, with the exception of respondent characteristics and qualitative analysis of comments.

Most respondents (73 of 134 or 54%) were in their second year of fellowship. There was a wide variety in program size and location (*see* Table 1 for fellow-reported details of training program characteristics).

Who Is the Primary Operator for Intubation?

We identified variation among institutional intubation practices as described by fellows. The majority of respondents indicated that the PCCM or IM-CCM fellow was the primary operator for intubation most of the time or more often, with 43% saying that they were "always or almost always" the primary operator and another 22% indicating that they had that role "most of the time." However, in a large minority (21%), the PCCM or IM-CCM fellow was rarely or never the primary operator for intubation in the MICU, with only 15% of respondents indicating their programs had more variation (Figure 1). Conversely, an anesthesiologist (or anesthesia team) was perceived by fellows as "always" the primary operator to intubate a MICU

Table 1. Description of 89 programs identified, 134 responses total

	Number (%)
Size of program	
10 or fewer fellows	31 (34.8)
11–17 fellows	36 (40.4)
18 or more fellows	22 (24.7)
Location of program	
Northeast	29 (32.6)
Southern	28 (31.5)
Central	20 (22.5)
Western	12 (13.5)

Fifteen respondents did not identify the name of their program; 92 distinct programs were identified but responses from 3 were unable to be used. Percentages use $N = 89$.

patient in 24% of programs and “most of the time” in another 9%.

Factors Affecting whether the PCCM Fellow Is the Primary Operator for Intubation

The most common factor identified as affecting whether the PCCM or IM-CCM fellow was the primary operator was the time of day, with verbal comments indicating that at night, many institutions rely on an anesthesiology team for intubation. After time of day, the supervising attending and which hospital the MICU was located in were equally

common factors influencing PCCM fellows’ intubating opportunities. Several respondents indicated that the MICU fellow was the primary operator for intubation in the MICU at one hospital whereas the anesthesiology team was the primary operator at another hospital within the same training program.

Qualitative analysis of free-text responses identified other factors that affect whether the PCCM or IM-CCM fellow intubates MICU patients: perceived difficulty of an airway, hospital policies regarding use of induction agents, ICU census and acuity, and requirement for attending presence.

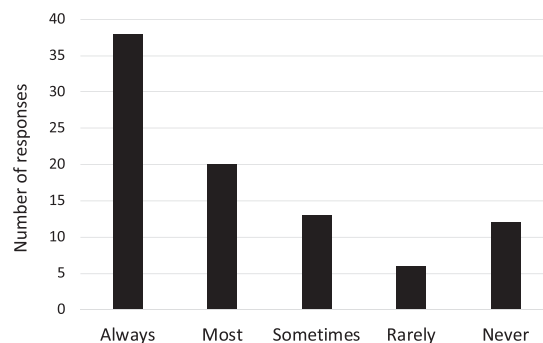


Figure 1. Variation by program in how often the Pulmonary and Critical Care Medicine fellow is the primary operator for intubating medical intensive care unit patients. Total number of responses is 89. Always = always or almost always; Most = most of the time.

MICU attending intubating privileges and preferences were also described as influencing fellows' intubation opportunities.

Program location was associated with whether the PCCM or IM-CCM fellow was the primary operator "always" or "most" of the time, compared with another answer ($P=0.04$). Respondents from Western, Central, and Southern programs were the primary operator "always" or "most of the time" more often than not, whereas the reverse was true for Northeastern programs (Table 2). There was no association between program size and whether the PCCM or IM-CCM fellow was the primary operator "always" or "most of the time" compared with less often ($P=0.23$).

At institutions where fellows identified that an anesthesiology team is present for MICU intubations, fellow comments also indicated that this interdisciplinary supervision had variable effects on PCCM fellows' learning. Multiple respondents indicated that anesthesiology was technically the primary operator but that the PCCM fellow could nonetheless intubate with the anesthesiologist's supervision—at the discretion of the attending anesthesiologist. Multiple respondents identified that airway experience was limited to controlled intubations in the operating room or bronchoscopy suite, and competition with other learners was identified as a factor in acquiring airway experience. Table 3 shows fellows' comments about factors influencing their ability to intubate in the ICU.

DISCUSSION

In a survey representing 89 distinct PCCM and IM-CCM programs in the United States, we demonstrated considerable variability in whether PCCM and IM-CCM fellows are the

primary operators intubating medical ICU patients. At about two-thirds of programs, fellows reported they are always or almost always given this role, but at nearly a quarter of training programs, the PCCM fellow is *rarely or never* the primary operator for a medical ICU intubation. We have also described factors influencing this variation in training: logistical factors (hospital policy, nighttime staffing, and ICU census and acuity), patient factors (perceived difficulty of the airway), and attending-specific factors. There was no association between whether PCCM and IM-CCM fellows were the primary operators for intubation and program size, whereas there was an association with region of the country. It is likely that regional differences are driven by institutional culture and policies alluded to in respondents' comments.

The strengths of this study include a high response rate and a broad representation of programs. Comments about fellowship intubation experience solicited by our survey overwhelmingly focused on barriers to ICU intubation experience and provide a starting place for further study.

Our results build on the estimates reported by Silverberg in 2014, in which 48% of PCCM program directors answered that their fellows performed 75–100% of intubations in the program's primary ICU (3). An important contribution of our work is that we have focused on the learner perspective: notably, *no* program directors in the Silverberg study answered that their fellows performed zero intubations in the program's primary ICU, and only 14% answered that their fellows performed fewer than 25% of the intubations. Furthermore, we have expanded this body of knowledge by exploring the factors that contribute to this variation in ICU intubation experience.

The number of ICU intubations in training required for competence is debated: a body of literature exists to suggest (conflicting) minimum numbers of successful intubations to achieve various metrics of success, with ranges of 30 to more than 150 intubations depending on the success rate measured and the setting (14, 15). In Silverberg's study, half of the program directors surveyed reported their fellows performed fewer than 50 intubations, which many experts would argue is insufficient for competence in the ICU setting, yet nearly all (92%) stated their fellows were comfortable intubating at the conclusion of fellowship (3). Ongoing research (16) will likely inform educational practice policy.

Although cumulative summation studies certainly provide a window into the relationship between experience and competence (15), trainee competence is not guaranteed by the number of procedures performed. Recent research in bronchoscopy (17) serves as an example that trainees acquire competence in procedures at different rates. Furthermore, there are avenues besides patient experience that can complement learning. For intubation (18), as for other procedures (19), the role of simulation is critical in ensuring competence among trainees, and simulation is used for low-frequency,

high-acuity event training for practicing anesthesiologists as well as trainees (18). Incorporating such simulation more broadly into both PCCM training and postgraduate intubation certification could mitigate some of the differences encountered in training.

The reported variation in ICU intubation experience during fellowship training has implications for the career paths of graduates of PCCM and IM-CCM fellowship programs. First, depending on the career goals of a graduating fellow, a different level of competence in airway management may be required. Some graduates will practice critical care at institutions where anesthesia "owns the airway," whereas others work at institutions where they are expected to be independent airway managers. Although professional societies and individual experts in the United States offer continuing medical education courses on airway management (20) that graduates of training programs could pursue, training after fellowship requires time and expense. As highlighted above, more robust simulation programs in both training and maintenance of certification may help mitigate differences in training, although it is likely that simulation will be necessary but not sufficient for competence in airway management.

Table 2. PCCM fellows' status as primary operator stratified by region

How Often Is PCCM Fellow the Primary Operator for ICU Intubation?	Region of Fellowship Program (Number)			
	Northeast	Southern	Central	Western
Always/most	13	22	15	8
Other	16	6	5	4

Definition of abbreviations: ICU = intensive care unit; PCCM = Pulmonary and Critical Care Medicine.

Answers of "always/almost always" and "most of the time" were compared with answers of "sometimes," "rarely," and "never." $P=0.04$.

One notable educational trend highlighted by our results is interdisciplinary supervision (anesthesiology attending supervising PCCM fellows for ICU intubations). Further work will need to explore features of this interdisciplinary teaching that are successful and those that can be improved. Our data suggest that interdisciplinary supervision occurs but did not determine whether or how interdisciplinary supervision might be

different from direct supervision by a PCCM attending. Furthermore, endotracheal intubation is not the only skill shared with providers in other specialties (tube thoracostomy and percutaneous tracheostomy are other examples). In an era in which medicine is increasingly specialized, being able to collaborate with educators and clinicians in other disciplines is critical.

Table 3. Additional factors influencing PCCM fellows' ICU intubation experience, by response to primary survey question

Factors Identified	Comment	How Often Is PCCM Fellow the Primary Operator for ICU Intubation?
Controlled intubations	"We do a rotation where we do OR intubations with anesthesia, aiming to get 20 airways (although very unhelpful given how difficult they are for ICU/emergent airways), option to do similar OR based rotation in upper years" (Respondent 64)	Never
Competition with other learners	"Intubations are learned through rotation with anesthesia in ORs. It is very challenging to get cases because of competition with other learners and attending preference" (Respondent 56)	Never
Controlled intubations		
Attending factors	"Our intubations depend on how comfortable supervising intensivist is" (Respondent 21)	Rarely
Fellow variation	"Minimal experience, we have the opportunity however to intubate more if we are aggressively seeking them" (Respondent 92)	Sometimes
Attending factors		
Perceived difficulty of airway	"[Depends on] MICU attending's comfort. Can be highly variable depending on hospital, attending, how busy it is, how acute and/or difficult the airway is" (Respondent 106)	Sometimes
ICU census/acuity		
Interdisciplinary supervision	"The best training/experience with airway management occurs when we intubate with our attending PCCM as we get experience in choosing appropriate sedation/paralytics and mode of laryngoscopy. When anesthesia [intubates] with us it is far less educational and usually a more chaotic scenario as they don't know the patients" (Respondent 129)	Most
ICU census/acuity		
Attending factors	"Attendings are very proactive in supporting and encouraging independence of fellows in intubating and performing procedures in general" (Respondent 36)	Always

Definition of abbreviations: ICU = intensive care unit; MICU = medical intensive care unit; OR = operating room; PCCM = Pulmonary and Critical Care Medicine.

Factors identified by qualitative analysis.

Our study has some limitations: although our data are representative of geographic and size variation of programs, they may nonetheless over- or underrepresent the number of programs where the PCCM fellow is always or almost always the primary operator for MICU intubations. Recall bias is certainly a possibility, but we note that with few exceptions, when there were multiple respondents from one institution, their responses were either identical or consistent (e.g., “always” and “most of the time.”) Nonresponse bias is also a possible limitation. Social desirability bias is also possible: that is, fellows may have felt pressure to respond favorably, and this could have biased the number of fellows stating they were “always” the first call to intubate. Again, given the consistency in multiple responses from the same institution, this seems unlikely. We did not ask about metrics of intubation success such as number performed, success rate, or complications. Given that most of our respondents were first- or second-year fellows, it is also likely that a report of number of intubations performed up to this point in training would have not accurately captured the pattern of a training program.

Endotracheal intubation in a critically ill patient is a complex task that requires a combination of technical skills, crew resource management expertise, and intimate knowledge of pathophysiology and pharmacology in critically ill patients. Future research should address *how* programs achieve competence in ICU airway management, particularly at institutions where anesthesia owns the airway, or where there is maximum variation. Further study should also

address how current variation affects fellows’ career development: for instance, do graduates of programs where the PCCM fellow is never or rarely the primary operator for intubation mainly work at institutions where they will not be airway managers? Do they seek additional experience outside of their fellowship program to gain competence? This study highlights the need for more data surrounding attainment of competence in airway management during training to unify training standards and inform hospital credentialing requirements.

Some barriers identified in our study, such as hospital policies surrounding use of induction agents, are likely beyond the scope of individual training programs to address. Therefore, broader changes within PCCM and IM-CCM education, such as requirements for simulation during and after training, may be needed to overcome variation in training to ensure PCCM and IM-CCM graduates’ competence in ICU airway management.

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REFERENCES

1. ACGME. ACGME program requirements for graduate medical education in pulmonary and critical care medicine. 2020. [accessed 2020 Oct 9]. Available from: https://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/156_PCCM_2020.pdf?ver=2020-06-29-162350-787.
2. Joffe AM, Liew EC, Olivar H, Dagal AH, Grabinsky A, Hallman M, *et al*. A national survey of airway management training in United States internal medicine-based critical care fellowship programs. *Respir Care* 2012;57:1084–1088.
3. Silverberg MJ, Kory P. Survey of video laryngoscopy use by U.S. critical care fellowship training programs. *Ann Am Thorac Soc* 2014;11:1225–1229.
4. Barsuk JH, Feinglass J, Kozmic SE, Hohmann SF, Ganger D, Wayne DB. Specialties performing paracentesis procedures at university hospitals: implications for training and certification. *J Hosp Med* 2014;9:162–168.
5. Kozmic SE, Wayne DB, Feinglass J, Hohmann SF, Barsuk JH. Factors associated with inpatient thoracentesis procedure quality at university hospitals. *Jt Comm J Qual Patient Saf* 2016;42:34–40.
6. Levitan RM, Rosenblatt B, Meiner EM, Reilly PM, Hollander JE. Alternating day emergency medicine and anesthesia resident responsibility for management of the trauma airway: a study of laryngoscopy performance and intubation success. *Ann Emerg Med* 2004;43:48–53.
7. Matic AA, Arndt G. “The critical airway”. *Can J Anaesth* 2005;52:993–995.
8. Jaber S, Amraoui J, Lefrant JY, Arich C, Cohendy R, Landreau L, *et al*. Clinical practice and risk factors for immediate complications of endotracheal intubation in the intensive care unit: a prospective, multiple-center study. *Crit Care Med* 2006;34:2355–2361.
9. De Jong A, Molinari N, Terzi N, Mongardon N, Arnal JM, Guitton C, *et al*.; AzuRéa Network for the Frida-Réa Study Group. Early identification of patients at risk for difficult intubation in the intensive care unit: development and validation of the MACOCHA score in a multicenter cohort study. *Am J Respir Crit Care Med* 2013;187:832–839.
10. Roux D, Reignier J, Thiery G, Boyer A, Hayon J, Souweine B, *et al*. Acquiring procedural skills in ICUs: a prospective multicenter study. *Crit Care Med* 2014;42:886–895.
11. Mosier JM, Malo J, Sakles JC, Hypes CD, Natt B, Snyder L, *et al*. The impact of a comprehensive airway management training program for pulmonary and critical care medicine fellows: a three-year experience. *Ann Am Thorac Soc* 2015;12:539–548.
12. Silverberg MJ, Li N, Acquah SO, Kory PD. Comparison of video laryngoscopy versus direct laryngoscopy during urgent endotracheal intubation: a randomized controlled trial. *Crit Care Med* 2015; 43:636–641.
13. ATS. Early career professionals: fellows track symposium. [accessed 2020 Oct 9]. Available from: <https://conference.thoracic.org/program/early-career-professionals/fellows-track-symposium.php>.
14. Konrad C, Schüpfer G, Wietlisbach M, Gerber H. Learning manual skills in anesthesiology: is there a recommended number of cases for anesthetic procedures? *Anesth Analg* 1998;86:635–639.
15. Bernhard M, Mohr S, Weigand MA, Martin E, Walther A. Developing the skill of endotracheal intubation: implication for emergency medicine. *Acta Anaesthesiol Scand* 2012;56:164–171.
16. Brown W, Janz DR, Russell D, Joffe EM, James DM, Vonderhaar DJ, *et al*. Effect of operator experience on outcomes of emergency airway management: the ICU intubation learning curve [abstract]. *Am J Respir Crit Care Med* 2020;201:A5985.

17. Voduc N, Adamson R, Kashgari A, Fenton M, Porhownick N, Wojnar M, *et al.* Development of learning curves for bronchoscopy: results of a multicenter study of pulmonary trainees. *Chest* [online ahead of print] 3 Jul 2020; DOI: 10.1016/j.chest.2020.06.046.
18. Komasawa N, Berg BW. Simulation-based airway management training for anesthesiologists - a brief review of its essential role in skills training for clinical competency. *J Educ Perioper Med* 2017;19: E612.
19. McGaghie WC, Issenberg SB, Barsuk JH, Wayne DB. A critical review of simulation-based mastery learning with translational outcomes. *Med Educ* 2014;48:375–385.
20. American College of Chest Physicians. Advanced airway management with cadavers. [accessed 2020 Oct 9]. Available from: <https://www.chestnet.org/Store/Products/Events/2020/Advanced-Airway-Management-With-Cadavers-November-2020>.