Undergraduate medical education in critical care

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Objective: **To review the current status of critical care education of medical students, focusing on how early, vigorous undergraduate training may address the needs of the learners and society.**

Data Sources: **Literature review of focused PubMed searches, online databases, and reference lists of recent publications.**

Results: **Although management of unstable and critically ill patients is required of most interns, undergraduate education in these skills remains largely elective, scattered, and highly variable. Critical care competencies for medical school graduates have not been established in the United States, and many students feel unprepared for these responsibilities that they assume as interns. Several successful approaches to medical student education in critical care have been demonstrated, and the availability of simulation technology provides new educational opportunities. Early exposure to other medical disciplines has influenced medical student career choice, although this has not been studied in regards to critical care fields.**

Conclusions: **Undergraduate medical education in critical care would be advanced by consolidation and organization into formal curricula. These would teach biomedical and humanistic skills essential to critical care but valuable in all medical settings. Early, well-planned exposure to critical care as a distinct discipline might increase student interest in careers in the field. The effects of educational interventions on the acquisition of knowledge, attitudes, and skills as well as long-term career choice should be subjected to rigorous study. (Crit Care Med 2012; 40:3065–3069)**

Key Words: medical education; medical student; undergraduate; workforce

Education in the care of the critically ill has never been more vital. Our understanding of the pathophysiology of critical illness has grown deeper. A widening body of influential clinical trials and guidelines informs patient management. Trainees must learn to practice in a landscape of changing patient safety, ethical and economic expectations. Work hour restrictions have reduced direct patient contact during residency training. Furthermore, over the next two decades, the critical care physician workforce is anticipated to fall short of needs by 30% as the populations of patients and physicians age (1, 2). Any solution to this workforce shortage must include inspiring a new generation to pursue our field.

Furthermore, the benefits of undergraduate education in the care of critically ill patients extend beyond the small subset of trainees who will choose to make this their career. The visible physiology in critical care reinforces lessons from preclinical courses. Intensive care units (ICUs) have been exemplars and laboratories for innovations in healthcare delivery that have disseminated throughout the health system. These include team-based care (3), the use of protocols and "bundles" to facilitate evidence-based practice (4–6), and simulation training (7–14) and checklists (15, 16) to improve communication and patient safety. Trainees learn teamwork, communication skills, managing information, organization, triage, ethics, and the technological limits of modern medicine. Furthermore, because most residency programs include experience caring for critically ill patients and much critical care in the community is delivered by hospitalists without specialty training, the need for early, quality education in critical care is ubiquitous.

A variety of *postgraduate* pathways to critical care specialization coexist in the U.S. training system (17). This review, however, will focus primarily on *undergraduate* education in critical care, the common aquifer that feeds these wells. Calls for strengthening of undergraduate critical care education have issued from the pages of *Critical Care Medicine* starting two decades ago (18), and have been echoed in this and other journals (19–22). This review will provide an update of current needs and opportunities.

NEEDS

Training in the care of critically ill patients is a requirement of the Accreditation Council for Graduate Medical Education for most residency programs. Intensive care unit experience is required during residency training in internal medicine, pediatrics, anesthesiology, emergency medicine, surgery, neurology, and obstetrics and gynecology (23). Together, these programs accounted for over two thirds of residency slots in the 2011 national residency match program (24). Furthermore, nearly all house officers will need to recognize and respond to inpatients whose condition becomes unstable.

In contrast with this widespread expectation for critical care experience during residency, such experience remains spotty during medical school. In a survey of the deans of 126 U.S. medical schools (88% response rate), all offered clinical rotations in critical care. However, in only 20% of responding schools was any clinical experience in critical care required, and not necessarily as a clerkship. Formal didactic curricula in critical care were offered in just 45% of medical schools, and this included Advanced Trauma or Cardiac Life Support courses. Although most schools reported observing students performing basic critical care procedures such as arterial puncture, bag-mask ventilation, or oxygen administration, the minority required demonstration of competence for graduation (25). An international survey of 210 English-speaking medical schools (60% response rate) found only 63% had a syllabus for

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critical care, which may be a marker for a structured curriculum. Among the 63 U.S. schools that responded, 85% offered critical care as an elective module (26). Results of a similar survey of all ICUs in Australia and New Zealand were recently published (27). Fifty-six percent of responding medical schools had mandatory educational programs in intensive care medicine topics, and 22% more offered electives. In only 30% did the total clinical teaching time in an ICU exceed 50 hrs (about a week).

The absence of a prescribed undergraduate curriculum in critical care does not necessarily indicate that acute care skills are not being taught. Critical care teaching may be distributed piecemeal throughout medical school training, appearing in clerkships such as emergency medicine, surgery, anesthesiology, or in focused courses such as Advanced Cardiac or Trauma Life Support (ACLS, ATLS) and Acute Life Threatening Events – Recognition and Treatment (ALERT) (28). However, the longitudinal, multidisciplinary, prognostic, ethical, and palliative (29) aspects of critical care may not be addressed in courses or settings centered on acute resuscitation. To overcome this shortcoming in the United Kingdom, the Acute Care Undergraduate Teaching Initiative used Delphi methodology to assemble a list of proposed competencies that all medical students should master before graduation (30). The American College of Critical Care Medicine has published guidelines for residency and specialty training, but has not addressed undergraduate medical training (31). Although elective rotations in an ICU are widely offered (25, 26), there is no systematic data available on what percent of students take advantage of these electives.

Despite the elective nature of most critical care course offerings, 84% of the international survey respondents felt that at least some critical care topics were "essential knowledge for junior doctors" (26). Similarly, in the recent survey from Australia and New Zealand ICUs, 80% of respondents felt that intensive care medicine should "definitely" be taught to medical students (27). To address competency acquisition in the final year of medical school, Lyss-Lerman et al (32) conducted structured interviews of program directors of the ten most popular residency specialties for graduates of the University of California, San Francisco School of Medicine. Many of the frequently cited competency deficits are easily addressed in the context of an ICU clerkship, including needs for greater organizational skills (cited by 33%), advanced communication skills (27%), and use of evidence-based medicine (30%). Furthermore, 43% specifically recommended that fourth-year medical students have a critical care rotation (32). Critical care knowledge is also expected for the purpose of medical licensure. In a review of a subset of questions on the National Board of Medical Examiners Step 2 exam, 19% of the questions were about critical care topics (25).

Finally, although procedural skill may be one of the less vital outcomes of a medical student critical care rotation, it is another area where many students are lacking experience. The Medical Students Outcomes Project, an initiative of the American Association of Medical Colleges, identified eight basic medical procedures, such as phlebotomy, starting an intravenous line, arterial puncture, and insertion of a nasogastric tube, that medical students should be able to perform before they graduate (33). Surveys of fourth-year students have found substantial fractions of students who have not performed any of these procedures. About half of residents in Internal Medicine do not feel prepared to lead a cardiac arrest team, a role that most of them must assume (34). Large fractions of students also do not feel confident of their ability to perform more basic, routine procedures (35–37).

Thus, although available data is limited, the following conclusions may be drawn:

1. New medical graduates will face rotations in critical care units, unstable patients, and critical care questions on their licensing board examinations.
2. Clinical elective rotations in critical care for medical students are widely available, but it is not known what percentage of graduates nationally take these electives.
3. Large numbers of students in the United States and elsewhere receive limited training or experience with routine medical procedures, and feel insecure about their skill.
4. Educators acknowledge the importance of gaining the skills associated with the care of critically ill patients early in medical training.

OPPORTUNITIES

Structured medical student education in critical care offers a number of potential opportunities to trainees and society. The most obvious benefit is improved care of the ICU patients students will soon face as interns and residents. However, improved communication skills, triage skills, understanding of patient safety protocols, multidisciplinary team management, palliative care, medical ethics, and the ability to manage data streams and time are all skills that serve patient care in many settings. To the extent that early exposure to the field can influence career choice, improved undergraduate experience may also benefit the manpower shortage in critical care.

Although the long-term effects of early experience in critical care remain unknown, some of the short-term benefits have been studied. The University of Pittsburgh School of Medicine offers a well-established and robust 4-wk elective clerkship in critical care. The rotation includes daily interactive conferences, frequent sessions of medical simulation training, and experiential training in an ICU. Before-and-after administration of multiple choice and essay examinations demonstrated substantial improvements in medical knowledge and reasoning. Furthermore, performance on an objective-structured clinical examination and complex medical simulation improved significantly (38–40). For procedural skills, students who completed a procedure course or a rotation in critical care, or emergency medicine were more likely to have performed basic medical procedures and more likely to feel adequate or competent in their abilities (36).

There is some evidence that introduction of critical care unit experience quite early in the medical school curriculum is well accepted and enjoyed by students. An elective rotation in critical care for second year preclinical students was recently introduced at the University of Washington School of Medicine. On a 1–5 scale from poor to excellent, the 50 participants rated the elective a mean of 4.87 in 2009 and 5.00 in 2010, and "much better" than other electives both years. The impact of this early exposure on subsequent career choice has yet to be studied (41). An 8-wk course reviewing critical care management for third- and fourth-year students at that school improved scores on an objective exam from 22 ± 10% to 86 ± 24%. During internship, 1–2 yrs after completion of the course, graduates rated its value as 9 ± 1 on a 10-point scale (42).

Thus, medical students completing critical care rotations do better on a critical care examination, express enthusiasm for the subject matter, and find the course

useful during subsequent training (29). Whether the skills learned during a student ICU rotation affect performance during residency or improve less tangible skills such as organization, teamwork, and communication are opportunities for research exploration.

The increasing availability of simulation-enhanced learning provides another opportunity for teaching ICU skills and competencies. Simulation takes many forms, including computer-based virtual patients, task-training stations, role-play, standardized patients, or high-fidelity manikins in a fully outfitted ICU room. Various simulation formats can be combined with experiential or didactic teaching in different curricula, and can be used both for training and assessment. Simulation has been applied throughout the spectrum of medical education from medical student to advanced practitioner, and is the subject of several recent reviews (8–11, 43).

The diverse permutations of medical simulation allow for a wide range of applications, but also make interpretation of the literature on their effectiveness challenging. A recent large meta-analysis incorporated 609 studies of simulation covering over 35,000 trainees (43). Heterogeneity between studies was high, and average study quality was relatively low. Most of the trials used knowledge tests or performance of a simulated task to assess the effects of the training. Among studies involving a total of 9,530 medical students, significant positive effects were seen in all of the studied domains of learning and behaviors. Only one of the studies of medical students measured effects on patients, and this study showed no significant benefits.

Other studies of simulation have used patient-centered outcomes, but have not focused on medical student trainees (11). In a study of simulation training for central venous catheter insertions by internal medicine house staff (13), training consisted of <2 hrs didactic and hands-on training in ultrasound use and insertion technique at the start of an ICU rotation. Complication rates were compared between periods before and after the introduction of the simulation training. Mechanical complication rate (including placement failure) fell from 32.9% to 22.9% ($p < .01$). The improvement was greater among interns (41.2% to 17.7%) than among more advanced trainees. Thus, although medical students were not subjects in this study, it suggests that the least experienced trainees may benefit the most from this form of training. The improvements demonstrated in this study have been echoed in others. A recently published meta-analysis of simulation training for central venous catheter placement (11) found a near halving of the risk for multiple needle passes or pneumothorax, and a relative risk for arterial puncture of 0.26 (confidence interval 0.08, 0.85). In studies focused on medical students, performance improvements after simulation training have been shown in complex trauma scenarios (14), myocardial infarction management (7), and neurologic critical care evaluation and management (12). However, simulation is costly in terms of staff development time, payments for standardized patients and, for high-fidelity manikins, acquisition and maintenance (44).

Increasing exposure of medical students to critical care may also provide an opportunity to kindle their interest in a career in the field. The American Thoracic Society convened a task force to address career attractiveness of Pulmonary and Critical Care Medicine. Interviews with Internal Medicine house staff revealed that they were often steered toward Pulmonary and Critical Care Medicine by their ICU experiences, specifically by the high-stakes medicine, the ability to see physiology in action, exposure to strong role models, and the ability to care for a wide range of issues (45). Early medical student exposure to other fields including surgery (46), vascular surgery (47), and primary care (48, 49) has been shown to positively influence their career choice.

The curriculum at the Johns Hopkins University School of Medicine has recently undergone a major revision (50). As part of this restructuring, a 4-wk, senior-year advanced clerkship in critical care has been made a requirement for graduation. The curriculum was derived using a formal development process (51, 52).

For the purposes of curriculum assessment, students completed anonymous 40-question pre- and post-clerkship surveys regarding their perceived levels of diagnostic and management skill for a variety of medical or surgical issues. Among the first 83 students to complete the clerkship, significant improvements were seen in virtually all aspects of the students' self-report. For example, the percent of students who agreed or strongly agreed with the statement, "I am comfortable personally initially assessing and managing an unstable patient" increased from 17% to 73% ($p < .001$). The percent who agreed or strongly agreed with the statement, "I know how to provide lung-protective ventilation to a patient with acute respiratory distress syndrome" increased from 8% to 87%, and the percent who agreed or strongly agreed that they knew the Surviving Sepsis Campaign guidelines for the management of severe sepsis (5) increased from 10% to 91% (both $p < .001$). More students felt prepared to start their internship on a critical care rotation (39% to 85%, $p < .001$). More students reported heightened career interest in critical care or related fields, but nearly half the cohort was interested even before starting the clerkship (48% to 57%, $p = .034$). Although this survey data alone cannot assess their competence, it indicates substantially greater comfort and familiarity with the management of critically ill patients. It may also spark or confirm career interest in the field.

SUMMARY AND RECOMMENDATIONS

It is essential that every medical school graduate acquire basic competencies that lie within the realm of critical care medicine. Care for unstable and complex critically ill patients will be expected of most interns. In addition to providing direct patient care experience, the ICU provides an environment in which to learn the skills of teamwork, communication, evidence-based medicine, palliation, and organization that are valued in any medical setting (Table 1).

However, despite the recognition of critical care medicine as a unique field, undergraduate medical education in critical care remains variable and often fragmented. Although elective clinical clerkships in ICUs are widely available, there are little data on how organized, comprehensive, or subscribed these are. This fragmentation and variable curricular emphasis may be the result of overlap between some competencies of critical care with those of other fields such as emergency medicine. It may also be the result of competing national or local priorities for enhanced training in primary care, ambulatory care, or other fields.

Motivated students will inevitably learn from an immersive experience, but that experience in an ICU can be overwhelming. Planned and structured curricula that include explicit goals, didactics, simulations, evaluation of competence, and evaluation of the curricular outcomes can ensure that all students extract

Table 1. Recommendations for undergraduate education in critical care

1. Undergraduate competencies for critical care should be established.
2. Medical schools should assess their curricula to determine whether these competencies are taught and assessed.
3. Curricular reform should address identified gaps in critical care education.
4. Assessment of curricular performance should accompany assessment of student performance, to include graduate performance, career choices, and patient outcomes.
5. Educational research should help identify pedagogical approaches that maximize these desired outcomes.

the most from the experience. Although a required student rotation will assure exposure, high-quality curricula and skilled instruction will attract students to elective rotations and raise the standards for other clerkships. Elective curricula can also be offered without reordering a medical school's existing priorities.

At a national level, we need consensus on the critical care knowledge, skills, and attitudes that should be expected of every medical school graduate, akin to what has been achieved at the graduate education level (31). Advocates for critical care education must make their case amid a babel of competing priorities. At the local level, schools can then begin to inventory where this material appears in their curricula and assemble the resources to fill the deficiencies. The investment in curriculum development will be repaid by interns who are more skilled and confident, and in patients who receive better care. This exposure at an early, formative stage may be reinforced by subsequent experience and steer trainees toward a lifetime of the satisfactions of our chosen field.

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