Concise review: Web-based resources for critical care education

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Objective: **To identify, catalog, and critically evaluate Web-based resources for critical care education.**

Data Sources: **A multilevel search strategy was utilized. Literature searches were conducted (from 1996 to May 31, 2010) using OVID-MEDLINE, PubMed, and the Cumulative Index to Nursing and Allied Health Literature with the terms "Web-based learning," "computer-assisted instruction," "e-learning," "critical care," "tutorials," "continuing education," "virtual learning," and "Web-based education." The Web sites of relevant critical care organizations (American College of Chest Physicians, American Society of Anesthesiologists, American Thoracic Society, European Society of Intensive Care Medicine, Society of Critical Care Medicine, World Federation of Societies of Intensive and Critical Care Medicine, American Association of Critical Care Nurses, and World Federation of Critical Care Nurses) were reviewed for the availability of e-learning resources. Finally, Internet searches and e-mail queries to critical care medicine fellowship program directors and members of national and international acute/critical care listserves were conducted to 1) identify the use of and 2) review and critique Web-based resources for critical care education.**

Data Extraction and Data Synthesis: **To ensure credibility of Web site information, Web sites were reviewed by three independent reviewers on the basis of the criteria of authority, objectivity, authenticity, accuracy, timeliness, relevance, and efficiency in conjunction with suggested formats for evaluating Web sites in the medical literature.**

Measurements and Main Results: **Literature searches using OVID-MEDLINE, PubMed, and the Cumulative Index to Nursing and Allied Health Literature resulted in >250 citations. Those pertinent to critical care provide examples of the integration of e-learning techniques, the development of specific resources, reports of the use of types of e-learning, including interactive tutorials, case studies, and simulation, and reports of student or learner satisfaction, among other general reviews of the benefits of utilizing e-learning. Review of the Web sites of relevant critical care organizations revealed the existence of a number of e-learning resources, including online critical care courses, tutorials, podcasts, webcasts, slide sets, and continuing medical education resources, some requiring membership or a fee to access. Respondents to listserve queries (>100) and critical care medicine fellowship director and advanced practice nursing educator e-mail queries (>50) identified the use of a number of tutorials, self-directed learning modules, and video-enhanced programs for critical care education and practice.**

Conclusions: **In all, >135 Web-based education resources exist, including video Web resources for critical care education in a variety of e-learning formats, such as tutorials, self-directed learning modules, interactive case studies, webcasts, podcasts, and video-enhanced programs. As identified by critical care educators and practitioners, e-learning is actively being integrated into critical care medicine and nursing training programs for continuing medical education and competency training purposes. Knowledge of available Web-based educational resources may enhance critical care practitioners' ongoing learning and clinical competence, although this has not been objectively measured to date. (Crit Care Med 2011; 39:000–000)**

KEY WORDS: e-learning; Web-based education; critical care education; continuing education; virtual learning

Integrating Web-based learning resources in medical education can enhance interactivity and has been demonstrated to improve satisfaction as well as facilitate learning efficiency (1–4). Web-based instructional methods are often categorized as e-learning, or the use of Internet technologies to enhance knowledge and performance (5–7). e-learning has been identified as a valuable tool for teaching and learning (8, 9). Methods of e-learning include self-paced tutorials, webcasts, podcasts, and interactive learning modules. e-learning has advanced from textbooks in electronic format to a highly interactive medium to enhance education for students and postgraduate learners (9). While information on the general use of Web-based learning is available, there is limited information on the use of Web-based resources for critical care education.

MATERIALS AND METHODS

Search Strategy. To identify and evaluate Web-based resources for critical care education, a multilevel search strategy was conducted. Literature searches (from 1996 to May 31, 2010) were conducted using OVID-MEDLINE, PubMed, and the Cumulative Index to Nursing and Allied Health Literature with the terms "Web-based learning," "computer-assisted instruction," "e-learning," "critical care," "tutorials," "continuing education" (CE), "virtual learning," and "Web-based education." We identified and searched the Web sites of relevant critical care organizations (American College of Chest Physicians, American Society of Anesthesiologists, American Thoracic Society, European Society of Intensive Care Medicine, Society of Critical Care Medicine [SCCM], World Federation of Societies of Intensive and Critical Care Medi-

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The authors have not disclosed any potential conflicts of interest.

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DOI: 10.1097/CCM.0b013e318206b5b5

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cine, American Association of Critical Care Nurses, and World Federation of Critical Care Nurses) for the availability of, or reference to, Web-based resources. We searched Info.com, a search engine combining Google, Yahoo Search, Bing, Ask, and About.com using combinations of the terms "e-learning," "critical care," "tutorials," "continuing education," "virtual learning," "Web-based education," and "video Web resources." Additionally, queries were sent to the following listserves: Critical Care Medicine Listserve (http://www.ccm-l.org/, >1,300 international members), Advanced Nursing Practice in Acute and Critical Care (http://health.groups.yahoo.com/group/ANPACC/, >1,000 international members), and World Federation of Critical Care Nurses. Lastly, a query was sent to the Critical Care Medicine Fellowship Director's Section of the SCCM (307 members) and to the National Organization of Nurse Practitioner Faculties Acute Care Section (>50 members) to assess current use of Web-based resources in educational training programs.

Data Extraction and Data Synthesis. To ensure the credibility of Web site information, Web sites were reviewed by three independent reviewers on the basis of the criteria of authority, objectivity, authenticity, accuracy, timeliness, relevance, and efficiency in conjunction with suggested formats for evaluating Web sites in the medical literature as outlined in Table 1 (10–15). To be included in this review, Web sites had to meet all criteria. Sites were evaluated on the basis of the seven categories, and those not meeting all seven criteria were not retained. Several Web sites were not deemed credible for various reasons, including unclear authorship, biased content, uncertain use of references, and out-of-date content (Web site not updated for 3 yrs or more) and therefore were not chosen for inclusion in this review. This review covers general critical care education and does not incorporate specialty-focused areas, such as pediatrics. Industry-sponsored Web sites were not included in this review.

Table 1. Criteria for evaluating educational Web sites

Authority: Authorship is a major criterion used in evaluating Web site information
Who created the information and why?
What knowledge or skills does the author/publishing body have in the area?
Note the URL of the document. Does the document reside on the Web server of an organization that has a clear interest in the issue at hand?
Objectivity
Is the information objective or subjective?
Is the information biased?
Is it full of fact or opinion?
Authenticity
Is the information authentic?
Is the information from an established organization?
Is this a primary source or secondary source of information?
Are original sources clear and documented?
Is a bibliography provided citing the sources used?
Reliability
Is the information accurate?
Does the information come from a school, business, or company site?
What is the purpose of the information resource, to inform, instruct, or persuade?
Timeliness
Is the information current?
How current are the sources or links?
Relevance
Does the information contain the breadth and depth needed?
Is the information helpful?
Is the information written in a form that is usable (i.e., reading level, technical level)?
Is the information in a form that is useful, such as words, pictures, charts, sounds, or video?
Efficiency
Is the information well organized, including a table of contents, index, menu, and other easy-to-follow tools for navigation?
Is the information presented in a way that is easy to use (i.e., fonts, graphics, headings)?

Adapted from Barker and Obramsook (10). Also see http://www.lib.berkeley.edu/TeachingLib/Guides/Internet/Evaluate.html, Engle (11), Johnson and Lamb (12), Kapoun (13), Kirk (14), and Tillman (15).

RESULTS

Literature searches using OVID-MEDLINE, PubMed, and the Cumulative Index to Nursing and Allied Health Literature resulted in >250 citations. These were searched for sources of Web-based resources and relevance to critical care medicine education. The published literature on the use of Web-based resources for medical education has focused on the general use of Web-based learning in medical education (16), the growth of e-learning options (17), perception of learning and satisfaction with online education (18), and critiquing the pros and cons of Web-based learning (19).

Those articles pertinent to critical care cover a broad range of topics, such as developing a critical care e-learning scenario (20), comparisons of traditional and Web-based learning formats for critical care courses (21), teaching cardiopulmonary resuscitation via the Web (22), Web-based tutorials for acute respiratory distress syndrome management (23), use of a Web-based antibiotic decision-making guide (24), evaluation of an online critical care course (25, 26), use of an educational Web site for echocardiography interpretation (27), development of a critical skills curriculum for surgical interns (28), use of a Web-based error reporting system (29), and use of simulation training in thoracic surgery residency (30), in critical care and trauma education (31), for teaching hemodynamic principles (32), and for the recognition of cardiac emergencies (33), among others.

No articles were found identifying Internet-based resources or sites for Web-based education for critical care.

Web Sites of Critical Care Organizations. Review of the Web sites of relevant critical care organizations revealed the existence of a number of e-learning resources. The SCCM Web site (http://www.sccm.org) offers various educational resources, including CE and continuing medical education (CME) content, slides from conference sessions, iCritical Care with links to podcasts, video podcasts for use with iPod Video and iTunes, and Critical Care Forum discussion groups. SCCM sponsors a resident intensive care unit (ICU) course that comprises two programs (adult ICU and pediatric ICU) targeting medical residents' knowledge acquisition during critical care rotations (http://www.learnicu.org/Clinical_Practice/Fundamentals/RICU/Pages/default.aspx). The resident ICU program contains zipped file links to handouts and slide presentations with the option for voice narration, case studies, self-assessment questions, and references for additional reading. Individual learners can take the course, but there is also the option for educational site directors to register trainees to provide them with access to the content as well as exams. The site director can also track his or her trainee's content access and exam performance.

SCCM's LearnICU Web site (http://www.learnicu.org) provides links to clinical practice guidelines developed under the auspices of the American College of Crit-

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ical Care Medicine, clinical topic webcasts, CME and CE activities, and other resources on a variety of critical care topics, including clinical practice, quality and safety, administration, and professionalism. A site map outlines available resources and topics: http://www.learnicu.org/Site_Map/Pages/default.aspx.

The American College of Chest Physicians Web site (http://www.chestnet.org/accp/) offers several Web-based educational resources, including evidence-based clinical practice guidelines, clinical resource guides, the Pulmonary Critical Care Sleep Update, which provides monthly educational reviews that offer CME, case puzzler clinical vignettes on various educational topics, slide kits (access requires membership), and CHEST-Soundings, a Web-based online CME education on various clinical topics with video presentations (access requires membership).

The American Thoracic Society Web site (http://www.thoracic.org) offers a variety of resources including an asthma center with clinical practice guidelines, guidelines on chronic obstructive pulmonary disease, and a critical care Web site with resources for interpretation of arterial blood gases, mechanical ventilation, and hemodynamic monitoring, including a Pulmonary Artery Catheter Primer. Other resources include teaching slides and guidelines for downloading into Palms and Image Library (access requires membership).

The European Society of Intensive Care Medicine Web site (http://www.esicm.org/) provides links to educational courses, information on competency-based training in critical care (Competency-Based Training in Intensive Care Medicine in Europe "Information Transfer"), and links to other critical care organizations. The European Society of Intensive Care Medicine's Patient-Centered Acute Care Training is a modular multidisciplinary distance-learning program focused on concepts of acute care medicine. The program contains 44 modules covering the ICU curriculum in various clinical areas, including clinical problems, organ-specific problems, skills and techniques, and professionalism (access requires membership).

The American Association of Critical Care Nurses Web site (http://www.aacn.org) offers a CE library with over 300 CE offerings (membership required), an e-learning program with courses (associated fees), clinical practice resource links, a collection of Web sites, and evidence-based practice resources related to critical care. An online ICU orientation program, Essentials of Critical Care Orientation, consists of 10 learning modules organized in a body systems approach to provide an introduction to critical care nursing. The program provides a total of 69 hrs of CE. The purchase of a site license is required to access Essentials of Critical Care Orientation.

The World Federation of Societies of Intensive and Critical Care Medicine Web site (http://www.world-critical-care.org) provides links to other critical care organizations, critical education conferences, and the Academy of Critical Care, a listing of papers, slide sets, and links to sites of interest (membership required for access). The World Federation of Critical Care Nurses Web site (http://en.wfccn.org/) outlines resources in several areas, including disaster management, cardiac, respiratory, and medical topics.

Resources Identified by Practitioners. In all, >100 responses were received from e-mail queries to national and international critical care medicine listserves (Critical Care Medicine Listserve, Advanced Nursing Practice in Acute and Critical Care, National Organization of Nurse Practitioner Faculties, World Federation of Critical Care Nurses) from a number of countries, including Australia, Canada, Europe, Japan, Singapore, South Africa, the United Kingdom, and the United States. A total of 52 responses were received from listserve queries to critical care medicine fellowship directors and advanced practice nursing educators. A number of Web-based resources were cited, including self-paced tutorials, learning modules, audio- and video-enhanced programs, online critical care courses, and sites for case studies and interactive educational modules.

Table 2. Types of e-learning available for critical care education and selected example Web site links

Interactive case studies	http://sprojects.mmi.mcgill.ca/heart/ecghome.html
Self paced tutorials	http://www.4 μm.com/tutorial/#Current%20Concepts
Virtual patients	http://www.elu.sgul.ac.uk/virtualpatients/examples.htm
Podcasts	http://www.sccm.org/Publications/iCritical_Care/Pages/Podcast_Archive.aspx
Webcasts	http://www.sccm.org/Conferences/Webcasts/Pages/default.aspx
Video podcasts	http://www.sccm.org/Publications/iCritical_Care/Pages/Vodcast.aspx
Image databanks	http://www.Trauma.org
Video-enhanced learning modules	http://www.cardiologysite.com/html/principles2.html
Three-dimensional animation	http://www.stethographics.com/main/physiology_3d_asthma.html
Instructional movies	http://videos.med.wisc.edu/category.php?categoryid=31
Self-assessment quizzes	http://www.skillstat.com/Flash/ACLS_Stat531.html
Interactive flashcards	http://www.12leadecg.com/intro/flashcards.aspx
Slide kits	http://www.lipidsonline.org/slides/

Table 2 outlines the range of e-learning formats, and Table 3 outlines Web site resources identified from this review that include education and teaching resources on a variety of topics pertinent to critical care. In all, >250 Web-based education and teaching resources were reviewed and critiqued to formulate the 135 resources identified in Table 3. An extensive description of each resource is beyond the scope of this review, but direct Web site link addresses are provided for readers' further review. Several sources for e-learning were frequently cited by critical care educators and clinicians, including SCCM's resident ICU course and LearnICU, the European Society of Intensive Care Medicine's Patient-Centered Acute Care Training, the American College of Chest Physicians Pulmonary Critical Care Sleep Update, and the American Thoracic Society's Pulmonary Artery Catheter Primer.

The Pulmonary Artery Catheter Education Project (http://www.pacep.org)

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Table 3. Topical index of Web-based resources for critical care education

Acid–base
http://www.anaesthesiamcq.com/AcidBaseBook/ABindex.php Provides a variety of acid—-base tutorials (advanced)
http://www.acidbase.org/ Reviews acid—base physiology (beginner) Recommended by critical care program directors
ARDS
ARDS support center, http://www.ards.org Provides information, education, and support resources for patients, survivors, and family members
Emedicine by WebMD, http://emedicine.medscape.com/article/808260-overview Adult respiratory distress syndrome: contains information on differential diagnoses, treatments, and medications
Medscape Today, www.medscape.com/viewarticle/466521 Lung recruitment in ARDS: physiologic concepts and practical strategies; discusses strategies such as prone positioning for ARDS treatment
Medscape, http://www.medscape.com/viewarticle/452476_4 Sepsis-associated shock, management of ARDS, and mechanical ventilatory strategies
Anatomy
Cardiac anatomy, http://www.skillstat.com/Flash/HeartScape531.html Anatomical overview of heart structure, electrical system, and explanation of basic terms of heart function, such as preload, afterload, etc; skills assessment quiz (beginner)
Dartmouth Medical School, http://www.dartmouth.edu/~anatomy/index.html Human anatomy learning modules (beginner)
University of Michigan Medical School, http://anatomy.med.umich.edu/courseinfo/module_index.html Medical gross anatomy learning module; contains modules on all systems, including test questions with each module (beginner) Recommended by critical care program directors
Anesthesia
John H Stroger Cook County Hospital Web site, http://cookcountyregional.com/ Contains information on local anesthetics, neuraxial anesthesia, peripheral nerve blocks, and other topics, including multiple videos related to anesthesia care (advanced) Recommended by critical care program directors
University of Florida's Virtual Anesthesia Machine, http://vam.anest.ufl.edu/ Contains free simulations on topics including the alveolar gas equation, airway devices for the difficult airway, and coronary circulation models; many of the simulations are interactive
Critical care medicine tutorials, http://www.4 μm.com/tutorial/#Current%20Concepts Tutorials on anesthesia, critical care medicine, pain management, regional anesthesia, and internal medicine (beginner and advanced) Recommended by critical care program directors
New York School of Regional Anesthesia, http://www.nysora.com/ Contains multiple evidence-based articles on regional anesthesia and pain management; site search engine available to assist in searching for specific topics
Arrhythmia and ECG interpretation
Cardiac rhythm simulator, http://www.skillstat.com/Flash/ECGSim531.html SkillsStat self-testing and assessment; ECG rhythm review with ECG rhythm identification test for assessment of skills (beginner)
Cardiac case studies, http://sprojects.mmi.mcgill.ca/heart/ecghome.html >40 cardiac cases that contain links that access 12 lead ECGs and a cath film (beginner)
Cardiac electrocardiograms, http://www.ecglibrary.com/ ECG library that contains rhythm strips with interpretations (beginner and advanced)
ECG Learning Center Tutorial, University of Utah, http://library.med.utah.edu/kw/ecg/ Contains both beginning and advanced information on ECG interpretation (beginner and advanced) Recommended by critical care program directors
12-lead ECG interpretation, University of Wisconsin, http://www.fammed.wisc.edu/pcc/ecg/ecg.html Offers both online video presentations on 12-lead ECG interpretation and lecture materials (beginner) Recommended by critical care program directors
Medstud.com ECG tutorial, http://www.drsegal.com/medstud/ecg/ Contains information on the basic physiology of the heart and electrical conductance along with all the more commonly addressed rhythms (beginner)
12-lead ECG interpretation, www.12leadecg.com/intro/ Includes quizzes, flashcards to use for further study, and practice ECG interpretation (beginner and advanced) Recommended by critical care program directors
University of Wisconsin, http://www.fammed.wisc.edu/our-department/media/614/ecg-course-1 Contains educational video on 12-lead ECG interpretation (beginner)
Arterial blood gas (ABG) interpretation
Arterial blood gas interpretation, http://orlandohealth.com/pdf%20folder/Inter%20of%20Arterial%20Blood%20Gas.pdf Self-learning module for interpretation of arterial blood gases (beginner) Recommended by critical care program directors
ABG self-learning module, http://www.scribd.com/doc/11816521/ABG-Self-Learning-Module-06 Provides an overview of ABG interpretation; case studies are included at the end for further evaluation of skills (beginner and advanced)

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Table 3.—*Continued*

Bioterrorism/disaster preparedness
SCCM disaster resources, http://www.sccm.org/Public_Health_and_Policy/Disaster_Resources/Pages/default.aspx Beginner and advanced____
Centers for Disease Control and Prevention, http://www.bt.cdc.gov/ Home page for emergency preparedness and response; gives links for bioterrorism, chemical emergencies, radiation emergencies, mass casualties, natural disasters, severe weather, and recent outbreaks and incidents
Federal Emergency Medicine Association, http://www.training.fema.gov/EMIWeb/IS/is100.asp, http://www.training.fema.gov/EMIWeb/IS/is200.asp, http://www.training.fema.gov/EMIWeb/IS/is701.asp Provides a number of interactive Web courses related to disaster management; reviews the structure of an incident command system (beginner and advanced)
Cardiovascular
Advanced cardiac life support, http://www.skillstat.com/Flash/ACLS_Stat531.html SkillsStat self-testing and assessment of advanced cardiac life support algorithms and medications (beginner)
Cardiac auscultation, http://www.wilkes.med.ucla.edu/intro.html Gives audible heart and lung sounds to help increase auscultation skills (beginner) Recommended by critical care program directors
Cardiologysite.com, http://www.cardiologysite.com Site includes instructional movies, three-dimensional animation of the heart, interactive heart sounds and murmurs, echocardiograms, and introduction to coronary angioplasty (beginner and advanced) Recommended by critical care program directors
University of Florida Vascular Biology Working Group, http://www.vbwg.org/meeting_highlights.cfm Offers multiple continuing education modules related to cardiovascular diseases and treatments
Baylor College of Medicine, http://www.lipidsonline.org Lipids online provides a slide library and educational modules related to topics in atherosclerosis, dyslipidemia, and lipid management (beginner and advanced) Recommended by critical care program directors
Baylor College of Medicine, http://www.hypertensiononline.org/home/about_HOL.cfm Hypertension online provides educational modules on topics related to hypertension (beginner and advanced) Recommended by critical care program directors
Cardiovillage, http://www.cardiovillage.com Sponsored by the University of Virginia Health System; provides access to online learning content in cardiology (beginner) Recommended by critical care program directors
Cardiac Trivia Challenge, http://www.skillstat.com/Flash/cardiacTrivia5_531.html SkillsStat self-testing and assessment; cardiac trivia question presented in a game setting_
Cardiologysite.com, http://www.cardiologysite.com Includes instructional movies, three-dimensional animation of the heart, interactive heart sounds and murmurs, echocardiograms, and introduction to coronary angioplasty. (beginner and advanced) Recommended by critical care program directors
Cardiac Dictionary, http://www.skillstat.com/Flash/cardiacDictionary531.html SkillsStat self-testing and assessment; simplistic alphabetical listing of heart terminology and definitions
SCCM's Cardiac Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Cardiac/Pages/default.aspx Includes webcasts, podcasts, and other information on hemodynamic monitoring, arrhythmias, cardiopulmonary resuscitation, and heart failure (beginner and advanced) Recommended by critical care program directors
Delirium
www.icudelirium.org/ Offers education and resources related to the monitoring and treatment of delirium for ICU patients and patient-oriented goal-directed sedation delivery; sponsored by The Delirium and Cognitive Impairment Study Group, Vanderbilt University Medical Center Geriatric Research Education Clinical Center, United States Department of Veterans Affairs, and Vanderbilt School of Medicine (beginner and advanced) Recommended by critical care program directors
End of life
SCCM's End of Life Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/End_of_Life/Pages/default.aspx Includes webcasts, podcasts, and other information on end-of-life issues (beginner and advanced) Recommended by critical care program directors
General critical care medicine
SCCM, http://www.learnicu.org/Quick_Links/Pages/default.aspx Contains links to guidelines and recommendations regarding various critical care topics, such as management of corticosteroid insufficiency, sepsis, hemodynamic support, etc. (beginner and advanced) Recommended by critical care program directors
SCCM resident ICU course, http://www.learnicu.org/Clinical_Practice/Fundamentals/RICU/Pages/default.aspx Consists of both adult ICU material and pediatric ICU material that was developed for residents to use during their rotation to critical care units; a wide variety of topics are covered and include airway management, neurologic and neurosurgical emergencies, shock and sepsis, etc; all content is presented in the form of a power point presentation (beginner and advanced)_ Recommended by critical care program directors

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Table 3.—*Continued*

European Society of Intensive Care Medicine'sPatient-Centered Acute Care Training, http://www.esicm.org/Data/ModuleGestionDeContenu/PagesGenerees/03-education/0B-pact-programme/25.asp
Modular multidisciplinary distance-learning program aimed at improving the quality of acute care medicine. The program contains 44 modules covering the ICU curriculum in various clinical areas of focus including clinical problems, organ specific problems, skills and techniques and professionalism. Membership is required for access. (Beginner and Advanced)
Recommended by critical care program directors

Critical Care A Day, http://www.icuroom.net
Provides critical care pearls, calculators/formulas, procedural videos, a database of critical care related articles and protocols, and other resources (beginner and advanced)
Recommended by critical care program directors

Medscape Critical Care CME, http://cme.medscape.com/criticalcare
Provides a variety of topics and case reviews related to critical care medicine (beginner and advanced)
Recommended by critical care program directors

Critical Care medicine tutorials, http://www.ccmtutorials.com/index.html-
Developed to assist medical residents during their critical care rotation in the surgical ICU at the University of Pennsylvania; provides instructional content and case studies on respiratory failure, shock, renal failure, and sepsis (beginner and advanced)
Recommended by critical care program directors

New England Journal of Medicine, http://content.nejm.org/misc/videos.dtl?ssource=recentVideos
Contains videos on an extensive listing of procedures related to critical care (beginner and advanced)
Recommended by critical care program directors

The Merck Manuals Online Medical Library, http://www.merck.com/mmpe/sec06.html
Contains links to information on treating critically ill patients including information on vascular access, respiratory and cardiac arrest, mechanical ventilation, etc.
Recommended by critical care program directors

SCCM's Critical Care Cross-Training for Hospital-Based Non-ICU Healthcare Providers, http://www.learnicu.org/Clinical_Practice/Fundamentals/Cross_Training/Pages/CourseContent.aspx
Provides information on the recognition and assessment of the seriously ill patient for healthcare providers who do not regularly care for critically ill patients

Hematology

SCCM's Hematology Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Hematology/Pages/default.aspx
Includes webcasts, podcasts, and other information on venous thromboembolism and transfusion (beginner and advanced)
Recommended by critical care program directors

Hemodynamic monitoring

Pulmonary Artery Catheter Education Program, http://www.pacep.org
Provides educational modules on the use of pulmonary artery catheters by presenting novice to expert instructional material along with challenging case studies for further learning (beginner and advanced)
Recommended by critical care program directors

Infectious disease/antibiotics

University of Washington School of Public Health, http://depts.washington.edu/eminf/2004/lectures.htm
Offers three infectious disease modules; the first module focuses on emergence of infectious disease and includes lectures on influenza and tuberculosis; the second module focuses on current challenges in infectious diseases and includes lectures on human immunodeficiency virus/acquired immunodeficiency syndrome and West Nile virus; the third module focuses on public health response and vaccine development

Centers for Disease Control and Prevention, www.cdc.gov/DRUGRESISTANCE/healthcare/ha/HASlideSet_clean.ppt
Power point slides to educate healthcare providers about drug resistance and the ways in which we can prevent antimicrobial resistance from occurring_

Johns Hopkins antibiotic guide, http://www.hopkins-abxguide.org/
Allows the practitioner to search information by diagnosis, pathogen, or antibiotic type; infectious disease considerations and recommendations are given where appropriate for diagnosis or pathogen (available to download to Palm)

SCCM's Infection Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Infection/Pages/default.aspx
Includes webcasts, podcasts, and other information on nosocomial, sepsis, infection control, and disease (beginner and advanced)
Recommended by critical care program directors

Laboratory tests

Labtestsonline, http://www.labtestsonline.org
Searchable lab test site for specific tests, conditions/diseases, or screenings; each topic is explained in simple terms and is correlated to a specific laboratory test (beginner and advanced)
Recommended by critical care program directors

Neurology/neurosurgery

National Institute of Neurologic Disorders and Stroke, http://www.ninds.nih.gov/disorders/disorder_index.htm
Contains index of multiple neurologic disorders and videos on neurologic topics

The Spine Center, http://www.spinecenterofdupage.com/video5-spine-procedures.html
Contains educational videos on conditions of the spine and surgical and nonsurgical spinal procedures

Foundation for Education and Research in Neurologic Emergencies, http://www.ferne.org/
Contains videos on the a variety of neurologic topics; Contains intracerebral hemorrhage and hypertensive emergency CME training modules

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Table 3.—*Continued*

Neuroland.com, http://www.neuroland.com
General Web reference for multiple neurologic disorders with multiple links and references (beginner)
Neurosurgeon.com, http://neurosurgeon.com/
Lists a variety of neuro topics; simplistic descriptions of certain conditions with fairly good accompanying pictures (beginner)
Christopher Reeves Spinal Cord Injury Resource Center, http://www.spinalinjury.net/
Discusses the basics of spinal cord injury and the possible sequelae related to the level of injury
Stroke Center, http://www.strokecenter.org/prof/
Resource on strokes; visit Stroke Information for Health Care Professionals review; anatomy and physiology; great diagnostic imaging section (beginner and advanced)
SCCM's Neurology Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Neurology/Pages/default.aspx
Includes webcasts, podcasts, and other information on head injury, sedation and delirium, stroke, and depression (beginner and advanced)
Recommended by critical care program directors

Nutrition in the Critically Ill

Critical Care Nutrition, www.criticalcarenutrition.com
Provides information on current research being performed in critical care nutrition as well as current guidelines for enteral vs. parenteral feeding in the critically ill adult (beginner and advanced)
Recommended by critical care program directors
Continuing Education in Nutrition Life Long Learning Program, http://lllnutrition.com/login/signup.php
In-depth nutritional education program focusing on the changing metabolic needs of the critically ill adult
SCCM's Nutrition Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Nutrition/Pages/default.aspx
Includes webcasts, podcasts, and other information on nutrition (beginner and advanced)
Recommended by critical care program directors

Pharmacology

Critical Care London, http://www.lhsc.on.ca/critcare/icu/drugs/drugindex.html
Critical care self-directed learning modules on analgesia, sedation, and delirium
Critical care medicine tutorials, http://www.4 μm.com/tutorial/#Current%20Concepts
Tutorials on anesthesia, critical care medicine, pain management, regional anesthesia, and internal medicine (beginner and advanced)
Recommended by critical care program directors
Pain Management—the online series—12 pain management online modules, American Medical Association, http://www.ama-cmeonline.com/pain_mgmt/
Provides in-depth information on pain from the pathophysiology of different types of pain to the assessment of the patient and evaluation of pain (beginner and advanced)
Recommended by critical care program directors
American Academy of Family Physicians, Chronic Pain—Interactive Case Studies, http://www.cpdgateway.com/ce-bin/owa/pkg_disclaimer_html.display?ip_cookie=29893227&ip_mode=secure&ip_test_id=12318&ip_company_code=CPD-
After a log-in is established, access to multiple continuing education modules including chronic pain and multiple other diseases is available (beginner and advanced)
Kaiser Permanente, http://nursingpathways.kp.org/national/learning/webvideo/programs/accc2_therapeutics/index.html#speaker
Online Web video presenting information on advanced critical care (inotropes, vasopressors, sedatives, opioids, and analgesics) (beginner and advanced)

Physical assessment

http://www.stethographics.com/main/physiology_ls_introduction.html
Presents basic heart sounds and lung sounds audibly (beginner)
University of Washington Department of Medicine, http://depts.washington.edu/physdx/heart/index.html
Advanced physical diagnosis Web site; contains heart tones and murmurs and tips for examining the heart, lungs, liver, and thyroid (beginner and advanced)
University of Florida, http://medinfo.ufl.edu/year1/bcs/clist/
Physical exam study guides for each body system; contains information on normal and abnormal findings (beginner)

Pulmonary

The Auscultation Assistant, http://www.wilkes.med.ucla.edu/lungintro.htm
Gives audible auscultation sounds of the normal lung, crackles, and wheezes (beginner and advanced)
Advanced Respiratory Assessment, http://www.teachertube.com/support_files/908.ppt#256,1,Advanced Respiratory Assessment: Auscultation
Power Point module outlining components of a respiratory assessment
Mechanical Ventilation, tutorial, http://www.ccmtutorials.com/rs/mv/
In-depth description of mechanical ventilation, the different modes used, and the varying techniques that are employed to maximize the patient oxygenation and ventilation (beginner and advanced)
Recommended by critical care program directors
California Society of Anesthesiologists, http://www.csahq.org/pdf/bulletin/crit_care_mod_57_3.pdf
Ventilator-associated pneumonia CME module
Kaiser Permanente, http://nursingpathways.kp.org/national/learning/webvideo/programs/accc3_resp/index.html
Online Web video presenting information on advanced critical care (ventilator modes, use of positive end-expiratory pressure, ABGs, and management of the patient with ARDS)
SCCM's Respiratory Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Respiratory/Pages/default.aspx
Includes webcasts, podcasts, and other information on respiratory, mechanical ventilation, and ventilator-associated pneumonia (beginner and advanced)
Recommended by critical care program directors

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Table 3.—*Continued*

Radiology
Learningradiology.com, http://www.learningradiology.com Provides lectures on multiple different chest topics including aspiration pneumonia, pleural effusion, and pneumonia; Also provides links to view chest x-rays of multiple topics (beginner and advanced)
Harvard Med School Chest Radiology, http://brighamrad.harvard.edu/education/online/clerk_2/read.html Contains a brief introduction to radiograph interpretation along with 11 case studies for specific conditions (beginner)
Yale Cardiothoracic Imaging, http://info.med.yale.edu/intmed/cardio/imaging/ Resource for learning cardiothoracic imaging; introduction to normal radiologic anatomy as well as explanations of various imaging techniques and the technology behind them; includes an index of case studies alphabetized by the specific condition (advanced)
Radiology Case Museum, http://myweb.lsbu.ac.uk/dirt/museum/museum.html Database of radiology examples
Chorus Hypertext of Radiology, http://chorus.rad.mcw.edu/ Contains various diagnostic testing images for multiple conditions; conditions are divided under system headings (i.e., cardiovascular, nervous system, etc.); Must be a subscriber of *BMJ* to visualize large versions of the diagnostic testing images
Goldminer, http://goldminer.arrs.org/ Search engine that understands medical terminology and has access to >200,000 radiologic images published in peer-reviewed journals
Chestx-ray.com, http://www.chestx-ray.com/Education/Education.html Contains multiple lectures on a variety of topics pertaining to thoracic imaging; the ABC's of blunt force trauma is an especially good lecture that helps the practitioner focus on specific common diagnoses after such things as a car accident (beginner and advanced)
Tutorial: CT in head trauma, http://www.radiology.co.uk/srs-x/tutors/cttrauma/tutor.htm Includes multiple types of head traumas and accompanying CT scans, including subdural hematomas, subarachnoid hematomas, intracranial air, etc. (beginner and advanced) Recommended by critical care program directors
Lobar Collapse Tutorial, http://www.radiology.co.uk/srs-x/tutors/collapse/tutorial.htm#extent Includes a thorough description of lobular collapse along with accompanying x-rays to demonstrate how lobular collapse appears on radiograph (beginner and advanced) Recommended by critical care program directors
Ultrasound in emergency and intensive care medicine, http://www.acidbase.org/echo/index.php Provides information on a variety of echography reviews, including abdominal, lung and pleura, liver and gallbladder, and others
UV Radiology Reviews Series
Introduction to Head CT, http://www.med-ed.virginia.edu/courses/rad/headct/ Reviews cranial anatomy, topics of trauma, stroke, degenerative diseases, infection, and tumor; all topics are accompanied with actual CT scan results to help the learner visualize the changes (beginner and advanced) Recommended by critical care program directors
UV Interpretation of the ICU Chest Film, http://www.med-ed.virginia.edu/courses/rad/chest/ Includes films of postoperative coronary artery bypass graft patients, how to identify nasogastric tube placement, intra-aortic balloon pump placement, Swan-Ganz catheter placement, etc. (beginner and advanced) Recommended by critical care program directors
UV Head CT, http://www.med-ed.virginia.edu/courses/rad/headct/index.html Introduction to reading head CTs self-learning module; reviews cranial anatomy on a CT scan as well as how to identify abnormalities that may occur with trauma, infection, stroke, and degenerative conditions (beginner and advanced) Recommended by critical care program directors
UV High Resolution Chest CT, http://www.med-ed.virginia.edu/courses/rad/hrct/index.htm Introduction to high resolution chest CTs; the module helps the beginner visualize such things as bronchiectasis, air trapping, honeycombing, and multiple other conditions on high-resolution CT (beginner and advanced) Recommended by critical care program directors
UV PET/CT, http://www.med-ed.virginia.edu/courses/rad/PETCT/index.html Introduction to PET/CT; introduces the reader to the uses of the PET scan with regard to cancer detection and staging (beginner and advanced) Recommended by critical care program directors
UV Abdominal CT, http://www.med-ed.virginia.edu/courses/rad/abdtrauma/index.html Introduction to total abdominal CT as used in trauma; the module also contains extensive information on the use of contrast and the indications for using different type of contrast in different situations (beginner and advanced) Recommended by critical care program directors
UV Ultrasound, http://www.med-ed.virginia.edu/courses/rad/edus/index.html Introduction to the use of ultrasound; defines ultrasound terminology and shows multiple different ultrasound views (beginner and advanced) Recommended by critical care program directors
UV Cardiac MRI, http://www.med-ed.virginia.edu/courses/rad/cardiacmr/index.html Introduction to the use of cardiac MRI; discusses the physics behind MRI as well as an introduction to anatomy identification on MRI and condition diagnosis. (Beginner and Advanced) Recommended by critical care program directors
UV GI Radiology, http://www.med-ed.virginia.edu/courses/rad/gi/index.html Introduction to gastrointestinal radiology including barium swallow, barium enema, cholangiography, upper GI, etc. (beginner and advanced) Recommended by critical care program directors
UV Genitourinary Radiology, http://www.med-ed.virginia.edu/courses/rad/gu/index.html Discusses the use of x-rays, CT scans, and ultrasound in the evaluation of the kidneys, ureters, and bladder (beginner and advanced) Recommended by critical care program directors
UV Cervical Spine Imaging, http://www.med-ed.virginia.edu/courses/rad/cspine/index.html Discusses the use of x-rays in the diagnosis of cervical spine injury; in-depth discussion of different views used in order to make accurate diagnoses (beginner and advanced)

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Table 3.—*Continued*

Recommended by critical care program directors
UV Skeletal Trauma, http://www.med-ed.virginia.edu/courses/rad/ext/index.html
Provides an introduction to diagnosing skeletal trauma by radiograph (beginner and advanced)
Recommended by critical care program directors
British Society of Echocardiography, http://www.bsecho.org/DLM%2015%20-%20Echo%20in%20Emergency-Acute%20Medicine%20Text.pdf
Learning module addresses the use of echocardiography in emergency medicine to diagnose a variety of conditions including pulmonary embolism, acute aortic syndrome, and refractory hyper/hypotension (beginner and advanced)
Vesalius Clinical Folios, http://www.vesalius.com/cfoli.asp
Addresses a wide variety of topics related to each body system
Organ System Modules
University Hospital of Cleveland, www.Uhrad.com
Contains links to multiple radiology case studies; each case study includes the accompanying radiologic testing pictures. Imaging that is addressed on this site include womens' imaging, neuro imaging, musculoskeletal imaging, Nuclear & SPECT imaging, PET scan, and body imaging (advanced)

Renal failure

Critical care medicine tutorials, http://www.ccmtutorials.com/
Home page contains a link to a tutorial on renal pathophysiology, oliguria, renal replacement therapies, and acid-base balance (beginner and advanced)
Recommended by critical care program directors
SCCM's Renal Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Renal/Pages/default.aspx
Includes webcasts, podcasts, and other information on renal topics (beginner and advanced)
Recommended by critical care program directors

Sepsis

Surviving Sepsis Campaign, http://www.survivingsepsis.org/Pages/default.aspx
An initiative of the SCCM and the European Society of Intensive Care Medicine developed to improve the management, diagnosis, and treatment of sepsis (beginner and advanced)
Recommended by critical care program directors
Medscape, http://www.medscape.com/viewarticle/452476_4
Sepsis-associated shock, management of ARDS, and mechanical ventilatory strategies
SCCM, http://www.learnicu.org/Quick_Links/Pages/default.aspx
Contains links to guidelines and recommendations regarding various critical care topics such as management of corticosteroid insufficiency, sepsis, hemodynamic support, etc. (beginner and advanced)
Recommended by critical care program directors

Suturing techniques

Boston University School of Medicine, http://www.bumc.bu.edu/generalsurgery/technical-training/basic-knot-tying-suturing/
from basic suturing to tying in central lines with video and interesting facts.

Therapeutic hypothermia

SCCM's Hypothermia Knowledge Line, http://www.learnicu.org/Clinical_Practice/Systems/Therapeutic-Hypothermia/Pages/HypothermiaPresentations.aspx
Includes webcasts, podcasts, and other information on therapeutic hypothermia (beginner and advanced)
Recommended by critical care program directors

Trauma

Trauma.org, http://www.trauma.org/resus/teamleader/teamleader.html
Provides a databank of images, case discussions, and articles that are useful references for trauma related topics (beginner and advanced)
Recommended by critical care program directors
Trauma Brain Injury Foundation, http://www.braintrauma.org
Provides guidelines for EMS and hospital management of patients with traumatic brain injury
John C Lincoln Hospitals, http://www.jcl.com/content/trauma/professional_education.html
Contains extensive trauma-related education for medical professionals_
University of Connecticut, http://www.conntutorials.com/chapter2.html
Video tutorial on the examination and management of the trauma patient
Centers for Disease Control, http://www.bt.cdc.gov/masscasualties/resources.asp
Navigate to the link labeled Public Health Professionals and Clinicians; contains information on what to do after terrorist bombing, blast injury fact sheet, mass brain injury, etc.
World Health Organization's Guidelines for Essential Trauma Care,
http://www.who.int/violence_injury_prevention/publications/services/guidelines_traumacare/en/index.html

General educational sites

Morbidity and Mortality Rounds on the Web, http://webmm.ahrq.gov/
Agency for Healthcare Research and Quality; covers a variety of clinical topics, patient safety issues, patient care issues with monthly topic discussions (beginner and advanced)
Recommended by critical care program directors
Clinical Cases and Images-Blog, http://casesblog.blogspot.com/2002/01/about-us.html
A comprehensive site for clinical cases and images (Beginner and Advanced)
Recommended by critical care program directors
The DAVE Project—Gastroenterology, http://daveproject.org/index.cfm
Contains educational and instructional videos pertaining to gastroenterology and endoscopy (beginner and advanced)

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Table 3.—*Continued*

Pathology at Pathology.org, http://pathlab.org/FNA_Cytology_Technique_Pathlab.org_Pathology_UK_Video_Cytology_Books_Media_News.html
Contains educational videos on the pathology related topics_____
Emedicine.com—from WebMD, http://www.emedicine.com
Contains up to date information on multiple topics
Medscape CME, http://cme.medscape.com
Provides a variety of CME articles and case studies in many specialty areas aside from critical care, including infectious diseases, internal medicine, cardiology, emergency medicine, radiology, surgery, and others
New Media Medicine, http://www.newmediamedicine.com
Offers video e-learning tutorials on multiple topics for doctors, medical students, and healthcare professionals; must register for site; registration is free
MedicalRounds.com, http://www.medicalrounds.com
Offers online continuing medical education for health careproviders through streaming video of medical rounds
Vesalius Clinical Folios, http://www.vesalius.com/cfoli.asp
Addresses a wide variety of topics related to each body system; easy to navigate and contains pictoral demonstrations of chest tube placement; also reviews abdominal CT scan interpretation
Baylor College of Medicine's Continuing Education Web site, http://www.baylorcme.org/specialty.cfm?menu_id=38
Offers continuing education on a variety of clinical topics
British Medical Journal Continuing Professional Education Web site, http://learning.bmj.com/learning/main.html
Contains multiple learning modules on topics ranging from COPD to diabetes to cancer; must register and pay fee to use site
Cleveland Clinic, http://www.clevelandclinicmeded.com/online/casebased/decisionmaking/
Continuing education modules; includes modules on AMI, thrombophlebitis, pancreatitis, fatty liver, thrombocytopenia, CAP, and others
MediCom Worldwide, http://medicomworldwide.com
Offers continuing education in the form of Web simulcasts as well as on-demand activities
Northwestern University Center for Genetic Medicine, http://www.feinberg.northwestern.edu/education/
Contains video lectures on genetics, primarily for healthcare professionals
University of North Carolina, http://www.med.unc.edu/cme/cme-enduring-materials
CME enduring materials and Web-based activities
University of Wisconsin-Madison. Innovation in Medical Education Video Library, http://videos.med.wisc.edu/category.php?categoryid=31
Contains educational videos on numerous topics for the healthcare professional; free registration
University of California Television, http://www.uctv.tv/meded/
Contains educational videos for faculty, students, staff, patients and others on multiple current healthcare topics

ARDS, acute respiratory distress syndrome; ECG, electrocardiogram; SCCM, Society of Critical Care Medicine; ICU, intensive care unit; CME, continuing medical education; CT, computed tomography; UV, University of Virginia; PET, positron emission tomography; MRI, magnetic resonance imaging.

Sites that target beginning learners (i.e., residents and graduate students) are indicated as "beginner." Sites that target advanced learners (i.e., fellows and critical care practitioners) are indicated as "advanced." Sites that were highly recommended by critical care program directors are indicated as "recommended."

was also frequently cited as a valuable resource for critical care education related to hemodynamic monitoring. The Pulmonary Artery Catheter Education Project is a collaborative educational effort sponsored by several organizations, including the American Thoracic Society, American College of Chest Physicians, SCCM, American Association of Critical Care Nurses, American Association of Nurse Anesthetists, American Society of Anesthesiologists, National Heart Lung Blood Institute, and Society of Cardiovascular Anesthesiologists. The program reviews the fundamentals of hemodynamic monitoring in a series of educational modules, including physiologic concepts, waveform analysis and interpretation, and technical aspects of monitoring. Registration is required to access the program.

Other frequently cited resources included the Critical Care Medicine Tutorial (http://www.ccmtutorials.com/index.html), which was developed to assist medical residents during their critical care rotation in the surgical ICU at the University of Pennsylvania. The tutorials provide instructional content and case studies on respiratory failure, shock, renal failure, and sepsis.

The Web site http://www.icuroom.net, developed by the critical care program directors at the University of Arkansas Medical Sciences College of Medicine and colleagues from the Baylor College of Medicine, Weill Cornell Medical College, and others, provides a daily ICU pearl, case studies, and links to a variety of resources, including training videos, power point presentations, and other resources.

As outlined in Table 3, quite an array of e-learning resources exist for critical care education. Figure 1 presents the most frequent topical categories of the Web-based resources. Many address specific aspects of care, such as radiology review, electrocardiogram tutorials, arrhythmia interpretation, arterial blood gas analysis, case study reviews, clinical cases, and critical care CME. Some are specific to clinical topics, such as acute respiratory distress syndrome, renal failure, sepsis, critical care nutrition, mechanical ventilation, antibiotic use, pain management, sedation, and delirium, among other topics. The Web site http://www.icudelirium.org zprovides assessment resources, tools, clinical practice guidelines, sedation scales and protocols, video reviews, and other resources. Additional Web sites provide databanks of images, including http://www.Trauma.org,

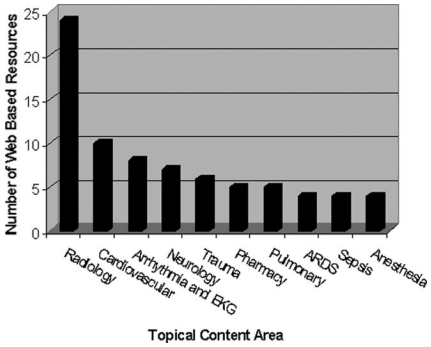

Figure 1. Most frequent topical content areas of Web-based resources for critical care education. *ARDS*, acute respiratory distress syndrome; *EKG*, electrocardiogram.

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which provides a databank of images, case discussions, and articles that are useful references for trauma-related topics.

Other Web sites target general case study reviews. The Agency for Healthcare Research and Quality's Morbidity and Mortality Rounds on the Web, http://webmm.ahrq.gov/, covers a variety of clinical topics, patient safety issues, and patient care issues with monthly topic discussions. A comprehensive site for clinical cases and images is the Clinical Cases and Images Blog (http://casesblog.blogspot.com/2002/01/about-us.html).

Several Web sites target family education, including ICU.USA (http://www.icu-usa.com), which promotes family education and communication by providing explanations on ICU-related medical conditions, drugs, procedures, equipment, and other aspects of the ICU environment. The acute respiratory distress syndrome support center (http://www.ards.org) provides education, support, and communication for patients, survivors, family members, medical personnel, and others interested in acute respiratory distress syndrome. A patient and family quick facts Web page on the ICU delirium Web site (http://www.icudelirium.org/patients.html) offers information on the definition of delirium and causes and management of delirium in critical illness, in addition to a downloadable delirium education brochure. The Web site also offers patient videos of survivors recalling their experiences, downloadable protocols for sedation, integration of ventilator/sedation/delirium strategies, and an extensive set of links to pertinent references. The Web site of the Institute for Family Centered Care (http://www.familycenteredcare.org/advance/orglm-links.html) provides general resources for family members on a variety of topics, including webinars, downloads related to patient-centered care, and information on patient and family resource centers. The American College of Chest Physicians established the Critical Care Family Assistance Program Web site (http://www.chestfoundation.org/foundation/critical/ccfap/index.php), which outlines the Critical Care Family Assistance Program model, created to meet the needs of families of critically ill patients through the provision of educational and family support resources. A sample set of Critical Care Family Assistance Program tools is available from the American Association of Critical Care Nurses Web site at http://www.aacn.org/WD/CETests/Media/CCFAP%20Study%20Guide.pdf.

While not a focus in this review, the use of simulation is an additional method of e-learning. In addition to the use of simulation manikins, general e-learning Web sites also include the use of virtual patient or interactive computer simulations (34–36). Virtual patient resources include the International Virtual Medical School (http://www.ivimeds.org), Virtual Patients (http://www.elu.sgul.ac.uk/virtualpatients/examples.htm), and Virtual Patient Working Group (http://www.medbiq.org/working_groups/virtual_patient/index.html) Web sites.

The reader is referred to Table 3 for further review of specific Web-based resources and encouraged to visit the individual Web sites and e-learning resources.

DISCUSSION

The Institute of Medicine's Committee on the Health Professions Education Summit highlighted the need to educate health professionals utilizing a variety of strategies to emphasize evidence-based practice, including the use of informatics (37). This review has identified over 135 Web-based resources for critical care education. Several strategies were used to locate resources, including literature reviews using established medical search strategies, review of the Web sites of critical care organizations, Internet searches, e-mail queries to critical care medicine fellowship program directors and advanced practice nursing educators, and e-mail queries to members of national and international acute/critical care listserves. The literature relating to the use of Web-based learning in critical care outlined examples of the integration of e-learning techniques, rather than providing information on the availability of specific resources. The literature review was useful in identifying strategies for integrating e-learning, outlining specific uses of e-learning and simulation, critiquing Web-based educational resources, identifying student or learner satisfaction, and summarizing the benefits of utilizing e-learning. Review of the Web sites of relevant critical care organizations was helpful in identifying a number of e-learning resources, including critical care courses, tutorials, podcasts, webcasts, slide sets, and CME resources. Internet search strategies and listserve queries to critical care educators and clinicians were the most useful in identifying specific resources for tutorials, self-directed learning modules, and video-enhanced programs for critical care education and practice.

Although a comprehensive multilevel search strategy was used, the results of this review are not exhaustive of all available Web-based resources. While the Internet provides a wealth of instructional resources, locating reliable sources for learning can be daunting. During data gathering, synthesis, and compilation of this review, which spanned a 1-yr duration, several Web sites were found to no longer be active, highlighting a limitation to Web-based educational resources. Additionally, some of the Web sites require registration or organizational membership to access; however, many of the educational resources are free of charge, highlighting the benefit of open access in facilitating e-learning.

It is well acknowledged that e-learning technologies are beneficial for education and competency training. Several specific benefits include having increased control over content learning and sequencing, the ability to pace learning, control over time allocated for learning activities, and the availability of enhanced media that allow the learner to tailor their personal learning experiences (38). As highlighted by comments from critical care educators and practitioners who provided information for this review, e-learning facilitates learning anywhere and at any time as Web-based resources are readily available and can be easily integrated into critical care educational programs and for CE purposes. Using e-learning resources also has potential time savings implications for learners in the face of work hour restrictions for physicians and limited funding for educational time for other critical care professionals.

Comparisons between e-learning and traditional methods of education, such as didactic lecture-based sessions, have demonstrated that e-learning is equivalent to traditional approaches of CE in achieving learning outcomes (39–44). In addition, the integration of e-learning in medical education has been found to result in enhanced learning, increased interactivity, and an improved self-learning experience (45–47). However, it becomes important that e-learning re-

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sources that are utilized in medical education are reliable and credible sources of information (7).

Strategies for integrating Web-based resources include ensuring access to resources during training programs. Electronic educational resources can be integrated with didactic learning and assessments through e-portfolios or clinical tools such as educational management systems (i.e., Blackboard). Programs such as SCCM's resident ICU enable program directors to register trainees and track their progress across content areas as well as their performance on exams. Self-assessments can then be used to provide feedback on progress and encourage learning. The Competency-Based Training in Intensive Care Medicine in Europe and Pulmonary Artery Catheter Education Project programs can be used to link educational resources to training competencies. These supplemental learning experiences can facilitate achievement of required competence for training as well as ongoing CE requirements.

Other strategies for integrating Web-based educational resources in training programs include the use of a wiki, or a Web site that allows the creation and editing of a number of Web pages. Trainees can also help to expand a learning library of education Web sites for programs, promoting intergenerational learning opportunities not only for residency or fellowship training but also for continuing professional education of critical care practitioners. It becomes evident that additional research is needed on the impact of integrating Web-based learning in critical care training programs. Simultaneously, sharing integration strategies being used by educators and soliciting feedback from trainees would enable ongoing development and utilization of Web-based educational modalities to enhance critical care education and training.

CONCLUSION

This concise review has outlined Web-based educational resources for critical care. An impressive number of Web-based resources exist for critical care education (>135) in a variety of e-learning formats, including tutorials, self-directed learning modules, webcasts, podcasts, and video-enhanced programs. As identified by critical care educators and practitioners who shared information on Web-based resources for this review, e-learning is being actively integrated into critical care medical and nursing training programs and for CME and competency training purposes. Web-based resources help to serve as knowledge tools for educators, students, and clinicians. Awareness of available Web-based educational resources may enhance critical care practitioners' ongoing learning and clinical competence, although this has not been objectively measured to date.

ACKNOWLEDGMENT

The assistance of Stefanie Bruinsma, RN, MS, ACNP, Nicole Devries, RN, MS, ACNP, and Nataki Williams, Rush University Medical Center, Chicago, IL, in collating and Web site review work is most appreciated.

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