

Review

Clinical review: Emergency department overcrowding and the potential impact on the critically ill

Robert M Cowan¹ and Stephen Trzeciak²

¹Chief Resident, Department of Emergency Medicine, UMDNJ-Robert Wood Johnson Medical School at Camden, Cooper University Hospital, Camden, New Jersey, USA

²Assistant Professor, Department of Emergency Medicine and the Section of Critical Care Medicine, UMDNJ-Robert Wood Johnson Medical School at Camden, Cooper University Hospital, Camden, New Jersey, USA

Corresponding author: Robert M Cowan, cowan-robert@cooperhealth.edu

Published online: 14 October 2004

This article is online at <http://ccforum.com/content/9/3/291>

© 2004 BioMed Central Ltd

Critical Care 2005, **9**:291-295 (DOI 10.1186/cc2981)

Abstract

Critical care constitutes a significant and growing proportion of the practice of emergency medicine. Emergency department (ED) overcrowding in the USA represents an emerging threat to patient safety and could have a significant impact on the critically ill. This review describes the causes and effects of ED overcrowding; explores the potential impact that ED overcrowding has on care of the critically ill ED patient; and identifies possible solutions, focusing on ED based critical care.

Introduction

Critical care begins immediately upon recognition of the critically ill (or potentially critically ill) patient, who has been defined as 'any patient who is physiologically unstable, requiring constant and minute-to-minute titration of therapy according to the evolution of the disease process' [1]. Therefore, the spectrum of critical care is not limited to the care that is provided within the confines of the intensive care unit (ICU). Rather, critical care begins (and is often necessitated) outside the ICU setting [2]. The nature of the illness rather than the location of the patient defines the need for critical care [1]; therefore, critical care patients are best defined physiologically rather than geographically. Outside the ICU and postoperative recovery rooms, critical care is most commonly provided in the emergency department (ED) [3].

Critical care constitutes a significant and growing proportion of ED practice [4–6]. Studies conducted in urban US EDs have reported that more than 150 days of critical care time are provided in an ED annually [5,6]. Many EDs have optimized their ability to deliver certain aspects of critical care for very specific scenarios, such as trauma, acute cerebrovascular accidents, and acute myocardial infarctions

(AMIs). Although EDs are designed to provide emergent stabilization and initial therapy for critically ill patients, most EDs do not have ICU-level resources for optimal longitudinal critical care delivery (such as uninterrupted 1 : 1 nursing care, focused subspecialty expertise, and invasive hemodynamic monitoring). Currently, the provision of critical care in the ED is increasing (in terms of both frequency and duration), largely because of ED overcrowding [5,7].

This review describes the causes and effects of ED overcrowding in the USA; explores the potential impact this has on the care of the critically ill ED patient; and identifies possible solutions, focusing on innovations in ED based critical care.

Emergency department overcrowding

In order to meet the increasing need for emergency services, many US EDs are being pushed to their maximum capacity. Although no strict definition exists, 'ED overcrowding' refers to an extreme volume of patients in ED treatment areas, forcing the ED to operate beyond its capacity [8]. This overcrowding is potentially associated with exceeding conventional nurse : patient ratios, providing medical care in makeshift patient care areas (e.g. triage areas and hallways), and diverting ambulances to other institutions [9]. Overcrowding usually leads to extremely long wait times, especially for those patients who are not critically ill, which leads to patient dissatisfaction, patient walkouts, and the potential for compromised medical care.

Although the exact incidence of ED overcrowding has not been studied in rigorous prospective investigations, widespread ED overcrowding has been cited by survey studies in

the literature [10–14]. According to a 2001 report, 91% of US ED directors (525 out of 575 directors) reported problematic crowding in their departments, and 39% reported overcrowding on a daily basis [11]. A recent survey conducted by the American Hospital Association reported that the percentage of large hospital EDs that are consistently operating ‘at or above capacity’ has reached 90% [14]. In the lay press, numerous reports have documented breaches of patient safety because of overcrowding, and these reports have questioned the ability of the entire US emergency care system to provide safe care during the current surge in demand for emergency services.

Causes

The causes of ED overcrowding are complex and multifactorial [15–17]. The primary determinants of ED overcrowding are not related to patient throughput inside the ED but actually originate outside the ED [18]. Of these, the two most important determinants of ED overcrowding pertaining to the critically ill are an increasing volume of high-acuity patients presenting to the ED and insufficient inpatient capacity.

Between 1992 and 1999, ED visits rose 14% from 89.8 million to 102.8 million visits annually, with the steepest gains in volume over the last 2 years of that time period [19]. While this increase in patient volume took place in the 1990s, 1128 EDs closed their doors [20]. As a result, more visits are being concentrated in fewer EDs. An increasing proportion of these patients are high-acuity patients who require critical care. Lambe and coworkers [7] reported a 59% increase in critically ill patients presenting to California EDs from 1990 to 1999. The increasing severity of illness among ED patients has been attributed to age shifts in the population and a higher prevalence of patients with severe chronic medical conditions. Considering the projected future growth in critically ill populations as a whole [21], this trend toward increasing severity of illness among ED patients will probably continue.

Although escalating patient acuity places a large strain on ED resources, the most important cause of ED overcrowding is insufficient inpatient capacity for ED patients who require hospital admission [8,22,23]. A lack of inpatient beds is also the most important contributor to ambulance diversion [24]. The number of inpatient hospital beds in the USA has declined sharply over the past 2 decades. Between 1981 and 1999 the total number of inpatient beds decreased by 39% [23]. This cutback has largely been the result of managed care initiatives and hospital cost-containment strategies. Eliminating inpatient beds maximizes the hospital census and ensures a ‘full house’ at all times, which is favorable from a financial standpoint [9]. However, when hospitals are perpetually functioning at greater than 90% of their inpatient capacity, they are ill equipped to handle surges in the number of admissions [25]. The current US nursing shortage exacerbates the lack of inpatient capacity by further decreasing the number of staffed beds available to offload an overcrowded ED.

Effects

Inadequate inpatient capacity for a patient population with increasing severity of illness forces the ED to serve as a holding area for admitted patients. The term ‘boarding’ refers to patients who are admitted to the hospital but who remain in the ED, sometimes for more than 24 hours, because of the lack of available beds [8,18,26]. Critically ill patients are no exception because ICU patients may also board in the ED for extraordinarily long periods until an ICU bed becomes available [4]. A recent report from the American Hospital Association [14] indicated that the average waiting time for an inpatient acute or critical care bed in US EDs is more than 3 hours, but the average waiting time nearly doubles (5.8 hours) in hospitals that consistently have ED overcrowding [14].

EDs are designed for rapid triage, stabilization, and initial treatment. When boarding in the ED causes a ‘gridlock’, the ED becomes the site for ongoing (i.e. longitudinal) care in the acute phase of hospitalization. In this scenario EDs must provide ongoing care for critically ill patients, effectively serving as expandable extensions of the ICU or ‘*de facto* ICUs’ [27]. However, EDs are not designed, equipped, or staffed to provide continuing care for the critically ill patient. Although most EDs have specialized areas in which they care for patients who present with trauma and AMI, most do not have the ability to perform invasive hemodynamic monitoring, including arterial and pulmonary artery catheterization. They are designed for rapid stabilization, including resuscitation from cardiac arrest (i.e. ‘code’ situations), but not for extended care.

Conventional ED nurse:patient ratios do not typically allow for the focused attention that a patient could receive in a critical care unit because most ED nurses are simultaneously responsible for numerous patients with varying severities of illness. When a nurse is assigned to an ICU patient boarding in the ED, one of two scenarios can be expected to occur; either the ideal 1:1 or 1:2 critical care nurse:patient ratio will be compromised, or the rest of the ED nursing staff will be required to absorb a greater proportion of ED patients.

Boarding in the ED is not only reported to be a barrier to specialized inpatient care, but it also has been identified as a potential high-risk environment for medical errors [8]. Critically ill patients boarding in the ED are physically separated from the watchful eye of the intensivists who are ultimately responsible for their care. All of these factors could potentially lead to delays in recognizing deterioration in a patient’s condition and in initiating critical interventions, and may detract from optimal patient care.

ED overcrowding has been reported to compromise patient safety, and the critically ill are an especially vulnerable population and are at-risk for serious adverse events. Although the impact of ED overcrowding on patient outcome has not yet been investigated in rigorous prospective

observational studies, survey studies in the literature have linked ED overcrowding to clinically significant delays in diagnosis and treatment, as well as to poor patient outcomes [10,15]. One report [10] linked ED overcrowding to delays in identification and treatment of time-sensitive conditions, such as acute coronary syndrome, stroke, surgical emergencies, and septic shock. ED overcrowding has also been shown to cause ambulance diversion and significant delays in ambulance transport for patients with acute cardiac emergencies [28,29], regardless of the severity of illness [28]. A recent study reported that ED overcrowding was associated with delays in door-to-needle time for AMI [30]. According to the Joint Commission on Accreditation of Healthcare Organizations [31], one half of all 'sentinel event' cases of poor outcomes that were attributable to delays in therapy originated in the ED, with ED overcrowding playing a role in almost one-third of these cases.

In addition to delays in therapy, ED overcrowding may also have an impact on the speed at which critical illness is recognized, through ambulance diversion, triage delays, and delays in bringing patients into treatment rooms. ED overcrowding may also result in extraordinarily long waiting times, causing some patients to leave the ED without being seen by a physician. Patients in the early hours of disease presentation who are initially well appearing and triaged as 'nonemergent' have the potential to leave the hospital without treatment and could become severely ill outside the hospital.

Boarding in the ED can subject critically ill patients to recognition and treatment delays at a pivotal point in the hospital course when time-sensitive interventions are necessary. Because optimal delivery of critical care in the early hours of disease presentation is often time-sensitive (i.e. cardiogenic shock [32], hemodynamic optimization in severe sepsis [33,34], and the 'golden hour' of trauma [35,36]), impediments to prompt critical care recognition and delivery in the ED setting could potentially represent a threat to patient safety.

Adding to the current landscape of ED critical care capacity is the potential threat of terrorism and other disasters. The readiness of US EDs to care for critically ill victims is a key element in preparedness for terrorism or bioterrorism. In a terrorist attack with either conventional or biologic weapons, a large volume of patients would be expected to require critical care services, including mechanical ventilation and hemodynamic support [37]. Overcrowded EDs could be poorly prepared to handle mass casualty victims [16].

Potential solutions: innovations in emergency department based critical care

There is no simple solution to ED overcrowding. Opinion leaders have reported that ED overcrowding will not be alleviated until hospitals adopt a multidisciplinary, system wide approach focused on solutions to inpatient capacity

constraints [18,27]. Strategic planning by hospital administration has been advocated by the Joint Commission on Accreditation of Healthcare Organizations [38], including expedition of patient transfers out of critical care areas, anticipation of delivery of care to patients who must be placed in temporary bed locations, and incorporation of ED overcrowding initiatives into hospital performance improvement goals. In addition, it has also been suggested that hospitals coordinate operating room scheduling (for patients who are likely to need ICU care postoperatively) with the anticipated cyclic patterns of increased ED patient visits, in which particular days have predictably higher ED volumes. Operating room scheduling is an important component of strategic planning for critical care needs and avoiding gridlock in the hospital [39].

Despite these steps, ED boarding in the USA is unlikely to be significantly alleviated in the near future. Thus, for any critically ill patient boarding in the ED, the ability to recognize and deliver prompt ED based critical care may be crucial in ensuring patient safety. In the era of ED boarding, innovative solutions are needed to provide alternatives to the ongoing acute phase management of the critically ill. If critically ill ED patients cannot be taken rapidly to the critical care unit, then it is necessary to find new ways to take critical care to the patient [3]. This is the concept of 'critical care without walls' [2].

ED based critical care is not intended to be a substitute for conventional critical care provided within the ICU, and neither is it intended to delay or hold a patient in the ED any longer than is absolutely necessary. Critical care provided in the ED would simply be a temporizing measure until an ICU bed becomes available. ED based critical care requires an institutional commitment to ED infrastructure. The necessary infrastructure would include the following components: a dedicated resuscitation area in the ED; ability to perform basic hemodynamic monitoring (i.e. including but not limited to measurements of central venous pressure, arterial blood pressure, and mixed venous/central venous oximetry); mechanical ventilation capability, including dedicated respiratory therapy staff; and a training program for ED nursing staff so that they may develop proficiency in hemodynamic monitoring and mechanical ventilation. All of these capabilities could be present in the Society for Academic Emergency Medicine's vision for a 'level one' emergency center [40].

For an emergency physician, the perpetual task of maximizing patient throughput for the entire ED is not compatible with the ongoing provision of comprehensive critical care for an individual patient. Therefore, the physician coverage for critical care patients boarding in the ED must be clearly defined. There are three different models for expanding physician coverage in order to provide ongoing focused critical care in the ED setting: the ICU-centric model, the ED-centric model, and the collaborative ED-ICU model.

The ICU-centric model

In the ICU-centric model, the critical care consultant would take over responsibility for any critically ill patient in the hospital at the time of patient identification, regardless of location. This would include critically ill patients boarding in the ED. Transfer of care would occur at the time of consultation, assuming that the patient meets criteria for admission to the critical care service. This would best be accomplished with an 'intensivist model' of staffing ICUs [41], in which a physician trained in multidisciplinary critical care is available around the clock [42]. For patients boarding in the ED, the emergency physician would still be in close proximity to respond to sudden major physiologic decompensations but they would not be responsible for ongoing critical care. This would allow the emergency physician to focus on patient throughput for the rest of the ED patients, and may also decrease 'hand-off' errors during patient transition because the intensivists would assume control earlier in the patient's course.

The ED-centric model

In the ED-centric model, responsibilities for patient care would be site defined. The ED physicians would take full responsibility for all critical care provided in the ED, regardless of how long a patient may be boarding there. Responsibility for patient care would not be transitioned to critical care staff until the patient arrives in the ICU.

One example of this model is the early intervention team (EIT) at Henry Ford Hospital (Detroit, MI, USA). Their ED-based EIT program was created to provide focused care for critically ill patients (specifically severe sepsis patients) in the ED setting. The EIT was founded on the principles that optimal delivery of critical care can be time sensitive, and that aggressive ED based critical care interventions can rapidly improve critical physiology and have a positive impact on outcome. The Department of Emergency Medicine provides all of the EIT infrastructure (including additional personnel, physician training, nursing training, physical plant modifications, and critical care equipment) and maintains the program exclusive from all inpatient critical care services. Essentially, they have built an acute-phase critical care unit in the ED. The EIT physicians send the patient to the inpatient ICU after prospectively defined end-points of resuscitation have been met. ED physicians (including resident physician trainees) staff the program and provide ongoing focused critical care at the bedside, allowing the other emergency physicians to focus on throughput for the noncritical ED patients (Rivers EP, personal communication, 2004).

The collaborative model

During the transition of patient care from ED to ICU staff, the use of collaborative evidence-based ED-ICU treatment protocols can help to facilitate uniformity of patient care. The use of protocols to complement clinical decision making for the critically ill has been shown to decrease unnecessary

variations in clinical practice [43]. Protocol-directed care has already gained acceptance in the management of glycemic control [44], sedation [45], and weaning from mechanical ventilation [46-48], but acute phase resuscitation can be guided by protocol as well [33,34]. Although applicable in all three models, collaborative protocols are more beneficial in this model because there will probably be variability in clinical decision making when patients are co-managed by two different teams of physicians. Collaborative protocols may help to reduce transitional errors and to streamline care.

At our institution (Cooper University Hospital, Camden, NJ, USA), a collaborative ED-ICU sepsis resuscitation protocol (an adaptation of the protocol described by Rivers and coworkers [34]) was recently adopted as an institutional 'best practice' model. The ED staff is responsible for patient identification and rapid protocol initiation. Per protocol, the critical care physician is automatically consulted at the time of patient identification for ongoing management. The protocol guides early resuscitative efforts in the ED and carries over to the initial phase of the ICU course as patient care is transitioned to the ICU team. Although transfer of patient care responsibilities (from ED to ICU services) officially occurs at the time of critical care consultation, the ED physicians continue to supervise protocol execution while the patient is boarding in the ED. Before instituting the resuscitation protocol, we held in-service training for our ED nursing staff and we trained all of our junior resident physicians in fundamental critical care support [49]. In the future, protocol directed resuscitation might be applicable to shock profiles other than sepsis. Conceptually, a collaborative ED-ICU model can facilitate a seamless transition on the continuum of critical care, as envisioned by the late Dr Peter Safar [50].

Conclusion

Critical care constitutes a significant and growing proportion of the practice of emergency medicine. ED overcrowding (i.e. 'boarding' in the ED) can have an adverse impact on patient safety, especially for the critically ill ED patient. Innovative solutions are needed to provide optimal care for the ongoing acute phase management of the critically ill in the ED setting.

Competing interests

The author(s) declare that they have no competing interests.

References

1. Brilli RJ, Spevetz A, Branson RD, Campbell GM, Cohen H, Dasta JF, Harvey MA, Kelley MA, Kelly KM, Rudis MI, *et al.*: **Critical care delivery in the intensive care unit: defining clinical roles and the best practice model.** *Crit Care Med* 2001, **29**:2007-2019.
2. Hillman K: **Critical care without walls.** *Curr Opin Crit Care* 2002, **8**:594-599.
3. Rivers EP, Nguyen HB, Huang DT, Donnino MW: **Critical care and emergency medicine.** *Curr Opin Crit Care* 2002, **8**:600-606.
4. Varon J, Fromm RE Jr, Levine RL: **Emergency department procedures and length of stay for critically ill medical patients.** *Ann Emerg Med* 1994, **23**:546-549.

5. Fromm RE Jr, Gibbs LR, McCallum WG, Niziol C, Babcock JC, Gueler AC, Levine RL: **Critical care in the emergency department: a time-based study.** *Crit Care Med* 1993, **21**:970-976.
6. Nelson M, Waldrop RD, Jones J, Randall Z: **Critical care provided in an urban emergency department.** *Am J Emerg Med* 1998, **16**:56-59.
7. Lambe S, Washington DL, Fink A, Herbst K, Liu H, Fosse JS, Asch SM: **Trends in the use and capacity of California's emergency departments, 1990-1999.** *Ann Emerg Med* 2002, **39**:389-396.
8. Gordon JA, Billings J, Asplin BR, Rhodes KV: **Safety net research in emergency medicine: proceedings of the Academic Emergency Medicine Consensus Conference on 'The Unraveling Safety Net'.** *Acad Emerg Med* 2001, **8**:1024-1029.
9. Schull MJ, Szalai JP, Schwartz B, Redelmeier DA: **Emergency department overcrowding following systematic hospital restructuring: trends at twenty hospitals over ten years.** *Acad Emerg Med* 2001, **8**:1037-1043.
10. Derlet RW, Richards JR: **Emergency department overcrowding in Florida, New York, and Texas.** *South Med J* 2002, **95**:846-849.
11. Derlet R, Richards J, Kravitz R: **Frequent overcrowding in U.S. emergency departments.** *Acad Emerg Med* 2001, **8**:151-155.
12. Andrulis DP, Kellermann A, Hintz EA, Hackman BB, Weslowski VB: **Emergency departments and crowding in United States teaching hospitals.** *Ann Emerg Med* 1991, **20**:980-986.
13. Richards JR, Navarro ML, Derlet RW: **Survey of directors of emergency departments in California on overcrowding.** *West J Med* 2000, **172**:385-388.
14. The Lewin Group: **Emergency Department Overload: A Growing Crisis. The Results of the American Hospital Association Survey of Emergency Department (ED) and hospital capacity. Vol. 2002, 2002.** [http://www.hospitalconnect.com/AHA/press_room-info/content/EdoCrisisSlides.pdf]
15. Derlet RW, Richards JR: **Overcrowding in the nation's emergency departments: complex causes and disturbing effects.** *Ann Emerg Med* 2000, **35**:63-68.
16. Trzeciak S, Rivers EP: **Emergency department overcrowding in the United States: an emerging threat to patient safety and public health.** *Emerg Med J* 2003, **20**:402-405.
17. Richardson LD, Hwang U: **Access to care: a review of the emergency medicine literature.** *Acad Emerg Med* 2001, **8**:1030-1036.
18. Schneider S, Zwemer F, Doniger A, Dick R, Czapranski T, Davis E: **Rochester, New York: a decade of emergency department overcrowding.** *Acad Emerg Med* 2001, **8**:1044-1050.
19. Burt CW, McCaig LF: **Trends in hospital emergency department utilization: United States, 1992-99.** *Vital Health Stat* 2001, **13**:1-34.
20. American College of Emergency Physicians: **Emergency medicine statistical profile 2001.** [<http://www.acep.org>]
21. Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J Jr: **Caring for the critically ill patient. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease: can we meet the requirements of an aging population?** *JAMA* 2000, **284**:2762-2770.
22. Richardson LD, Asplin BR, Lowe RA: **Emergency department crowding as a health policy issue: past development, future directions.** *Ann Emerg Med* 2002, **40**:388-393.
23. American Hospital Association. **Hospital Statistics, 1999.** [<http://www.hospitalconnect.com/healthforum/hfstats/downloads.html>]
24. Schull MJ, Lazier K, Vermeulen M, Mawhinney S, Morrison LJ: **Emergency department contributors to ambulance diversion: a quantitative analysis.** *Ann Emerg Med* 2003, **41**:467-476.
25. Bagust A, Place M, Posnett JW: **Dynamics of bed use in accommodating emergency admissions: stochastic simulation model.** *BMJ* 1999, **319**:155-158.
26. Henry M: **Overcrowding in America's emergency departments: inpatient wards replace emergency care.** *Acad Emerg Med* 2001, **8**:188-189.
27. Derlet RW: **Overcrowding in emergency departments: increased demand and decreased capacity.** *Ann Emerg Med* 2002, **39**:430-432.
28. Schull MJ, Morrison LJ, Vermeulen M, Redelmeier DA: **Emergency department gridlock and out-of-hospital delays for cardiac patients.** *Acad Emerg Med* 2003, **10**:709-716.
29. Schull MJ, Morrison LJ, Vermeulen M, Redelmeier DA: **Emergency department overcrowding and ambulance transport delays for patients with chest pain.** *CMAJ* 2003, **168**:277-283.
30. Schull MJ: **Overcrowding of Ontario emergency departments and door-to-needle time delays in acute myocardial infarction [abstract].** *Can J Emerg Med*, in press.
31. Joint Commission on Accreditation of Healthcare Organizations (JCAHO): **Sentinel Event Alert 2002, Issue 26.** [http://www.jcaho.org/about+us/news+letters/sentinel+event+alert/print/sea_26.htm]
32. Hochman JS, Sleeper LA, Webb JG, Sanborn TA, White HD, Talley JD, Buller CE, Jacobs AK, Slater JN, Col J, et al.: **Early revascularization in acute myocardial infarction complicated by cardiogenic shock. SHOCK Investigators. Should we emergently revascularize occluded coronaries for cardiogenic shock?** *N Engl J Med* 1999, **341**:625-634.
33. Carcillo JA, Fields AI: **Clinical practice parameters for hemodynamic support of pediatric and neonatal patients in septic shock.** *Crit Care Med* 2002, **30**:1365-1378.
34. Rivers E, Nguyen B, Havstad S, Ressler J, Muzzin A, Knoblich B, Peterson E, Tomlanovich M; Early Goal-Directed Therapy Collaborative Group: **Early goal-directed therapy in the treatment of severe sepsis and septic shock.** *N Engl J Med* 2001, **345**:1368-1377.
35. Cowley RA: **The resuscitation and stabilization of major multiple trauma patients in a trauma center environment.** *Clin Med* 1976, **83**:16-22.
36. Blow O, Magliore L, Claridge JA, Butler K, Young JS: **The golden hour and the silver day: detection and correction of occult hypoperfusion within 24 hours improves outcome from major trauma.** *J Trauma* 1999, **47**:964-969.
37. Karwa M, Bronzert P, Kvetan V: **Bioterrorism and critical care.** *Crit Care Clin* 2003, **19**:279-313.
38. Joint Commission on Accreditation of Healthcare Organizations (JCAHO): **Emergency department overcrowding field review.** [http://www.jcaho.org/accredited+organizations/hospitals/standards/field+reviews/ed_fr_std.htm]
39. McManus ML, Long MC, Cooper A, Mandell J, Berwick DM, Pagano M, Litvak E: **Variability in surgical caseload and access to intensive care services.** *Anesthesiology* 2003, **98**:1491-1496.
40. Goldfrank L, Henneman PL, Ling LJ, Prescott JE, Rosen C, Sama A: **Emergency center categorization standards.** *Acad Emerg Med* 1999, **6**:638-655.
41. Pronovost PJ, Angus DC, Dorman T, Robinson KA, Dremiszov TT, Young TL: **Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review.** *JAMA* 2002, **288**:2151-2162.
42. The Leapfrog Group: **Fact Sheet: ICU Staff.** The Leapfrog Group for Patient Safety; 2004. [http://www.leapfroggroup.org/factsheets/ICU_FactSheet.pdf]
43. Holcomb BW, Wheeler AP, Ely EW: **New ways to reduce unnecessary variation and improve outcomes in the intensive care unit.** *Curr Opin Crit Care* 2001, **7**:304-311.
44. Brown G, Dodek P: **Intravenous insulin nomogram improves blood glucose control in the critically ill.** *Crit Care Med* 2001, **29**:1714-1719.
45. Brook AD, Ahrens TS, Schaiff R, Prentice D, Sherman G, Shannon W, Kollef MH: **Effect of a nursing-implemented sedation protocol on the duration of mechanical ventilation.** *Crit Care Med* 1999, **27**:2609-2615.
46. Ely EW, Meade MO, Haponik EF, Kollef MH, Cook DJ, Guyatt GH, Stoller JK: **Mechanical ventilator weaning protocols driven by nonphysician health-care professionals: evidence-based clinical practice guidelines.** *Chest* 2001, **Suppl**:454S-463S.
47. Kollef MH, Shapiro SD, Silver P, St John RE, Prentice D, Sauer S, Ahrens TS, Shannon W, Baker-Clinkscale D: **A randomized, controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation.** *Crit Care Med* 1997, **25**:567-574.
48. Marelich GP, Murin S, Battistella F, Inciardi J, Vierra T, Roby M: **Protocol weaning of mechanical ventilation in medical and surgical patients by respiratory care practitioners and nurses: effect on weaning time and incidence of ventilator-associated pneumonia.** *Chest* 2000, **118**:459-467.
49. Dellinger RP: **Fundamental critical care support: another merit badge or more?** *Crit Care Med* 1996, **24**:556-557.
50. Safar P: **The critical care continuum from scene to outcome.** In *Major Issues in Critical Care Medicine*. Edited by Parrillo JE, Ayers SM. Baltimore, MD: Williams and Wilkins; 1984:71-84.