

REVIEW

Year in review 2011: *Critical Care* – Resource Management

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Abstract

Increasing complexity and costs are a fundamental problem in critical care medicine, leading researchers to study opportunities and threats to continue to provide high-quality care in a more efficient health system. Over the past decades, we have learned from industrial methods that quality improvement and resource management can help achieve these results. Last year, *Critical Care* published a number of papers that highlight key points of critical care resource management. Each of these is grouped into one of three broad categories, based on domains of quality: (a) outcomes, in which we review long-term outcome data with an emphasis on the aging population, strategies to help mitigate the psychological burden of critical care, adverse events, and the appropriate use of resources, such as prolonged mechanical ventilation and intensive care unit (ICU) beds; (b) processes of care, in which we review variability in the provision of critical care, owing to gender, insurance status, and delays in ICU admission; knowledge translation studies in critical care; goal-directed therapy for postoperative patients and decision-making in the ICU; and (c) structure, in which we review strategies to improve quality through changes in design and the structural limitations to provide care in resource-limited settings.

Introduction

Last year, *Critical Care* published several important original articles addressing intensive care unit (ICU) resource management. To provide the reader with better context, these are reviewed by using three domains of quality – outcomes, processes, and structure – as a framework.

Outcomes

Long-term outcomes

As a result of the increasing aging of the population, an increased population of older patients is being admitted to the ICU in different countries [1]. Compelling data show that advanced age leads to restrictions in ICU admission and in intensity of treatment [2]. However, this seems hardly justified based on the currently available data. For example, in a cohort of 299 patients who were at least 80 years old, survival to hospital discharge was 45%, and the median survival time was almost 2 years. Interestingly, the authors did not observe an association with pre-morbid functional status and 2-year mortality. Only severity of illness at ICU admission and the severity of underlying diseases, assessed by the McCabe score, predicted long-term mortality [3]. These are important data for clinicians as we tend to be biased by the large number of older patients dying in the ICU and we frequently do not know the long-term outcomes of the survivors. Furthermore, the authors were able to document health-related quality of life in a small subset of the survivors 5 years after discharge. Although SF-36 (Short Form Health Survey-36) scores for physical function were lower when compared with a population of octogenarians who were not admitted to an ICU, the scores for bodily pain, emotional well-being, social function, and emotional role were not much affected. In a more comprehensive analysis of quality of life in older patients, Sacanella and colleagues [4] evaluated the functional status of previously healthy and autonomous patients who were older than 65 years, had no cognitive impairment, and were admitted non-electively to a medical ICU. Twelve months after discharge, 49% of patients were alive and there were statistically significant decreases in functional autonomy (Lawton and Barthel indices) and quality of life (EuroQol-5D) compared with baseline status. Geriatric syndromes increased after ICU admission and remained significantly increased during follow-up [4]. However, this must be put into context. First, baseline assessment was done at ICU admission, and this may lead to ascertainment bias (the patient or the next-of-kin may overestimate quality of life and functional status at admission). Second, for patients

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unable to communicate, the assessment was done by relatives and this could lead to biases as well; fortunately, another paper demonstrated that the scoring of disability by relatives in close contact had a high correlation to the scores of patients, and this increases the validity of their findings [5]. Third, even if the assessment was unbiased, autonomy was actually normal in 73% of patients, cognition was normal in 85% of patients, 69% of patients did not have a significant decrease in quality of life, and 63% did not develop more than one geriatric condition. Although authors tend to report on decreased quality of life and functional status after the ICU, we can observe from this cohort that the vast majority of patients were mainly unaffected. Furthermore, larger cohorts that were able to collect unbiased baseline measures could not observe an increase in the majority of geriatric conditions after sepsis, when properly controlled for confounders [6].

ICU survivors may experience psychological distress, developing symptoms compatible with anxiety, depression, and post-traumatic stress disorder (PTSD) [7]. The periods before and after the introduction of a clinical psychology service for ICU patients, which provided education, counseling, and stress management at the bedside, provided the opportunity to observe the effects of this intervention on clinical outcomes [8]. Probably the most striking results were a decreased incidence of PTSD (21% versus 57%) and a reduction in the use of psychiatric medications (8% versus 41%) in the intervention group [8]. Further studies, ideally blinding the adjudication of outcomes to the intervention, should reproduce these findings before a wider acceptance.

Resource utilization

Another patient category that seems to be increasingly common in the ICU consists of patients undergoing prolonged mechanical ventilation (PMV) [9]. Lone and Walsh [10] studied characteristics and outcomes of a PMV cohort in the UK. Although the incidence of PMV was 4.4 per 100 ICU admissions, patients requiring PMV used almost one third of all ICU bed days available, stayed longer in the hospital after ICU discharge than non-PMV patients (median 17 versus 7 days, $P < 0.001$), and had higher hospital mortality (40.3% versus 33.8%, $P = 0.02$) [10]. Another interesting report from Taiwan confirmed the trends in utilization, as the investigators observed a doubling of the rates of ICU utilization by patients undergoing PMV in their health-care system, demonstrating the need to consider these patients in calculations for critical care resource needs [11]. The investigators also found that PMV patients with degenerative neurological diseases, stroke, or injuries tended to live longer than those with chronic renal failure or cancer [11].

ICU beds and staffing will be increasingly required because of the combination of aging of the population, larger numbers of patients using prolonged mechanical ventilation, and the effects of pandemics, such as H1N1, which required substantial ICU resources in Australia and New Zealand [12]. Societies will need to make decisions on increasing resources or rationing beds. A large multicenter study from Europe provides some guidance into the cost-effectiveness of ICUs. The authors compared clinical and economical outcomes for patients admitted to an ICU versus those denied ICU admission. The odds ratio (OR) for mortality after an ICU admission was 0.70 and the costs per life-year saved USD \$7,065, both suggesting that ICUs not only are clinically effective but also compare favorably with other therapies regarded as essential [13].

Predicting outcomes for patients outside the ICU

Critical care medicine has a long tradition in the use of scoring systems for prognostication [14]; however, very few scores have real clinical utility for the individual patient since they measure the average risk of a population and cannot replace clinical judgment given that there is much uncertainty in deciding to withdraw or withhold treatments [15]. However, few studies look into the opportunity to offer critical care to patients who are not in the ICU, where scores could help. As sepsis is a dynamic condition, scoring systems may identify earlier those ward patients who are at risk of progression to life-threatening disease and who may benefit from higher levels of care. One study looked into four different scoring systems for septic patients admitted to a general internal medicine ward. Mortality was strikingly high for this population, just beyond 20%, and the scores had a discriminatory power that was moderately helpful, ranging in areas under the curve (AUCs) from 0.69 to 0.77 [16]. A similar study addressed the use of eight different scoring systems for pneumonia in patients with hospital-acquired pneumonia [17] and their predictive ability for 30-day mortality and 14-day admission to an ICU. Mortality was again quite high (above 20%), and almost 30% of patients were admitted to an ICU. The AUCs ranged from 0.58 to 0.71 for mortality and from 0.69 to 0.82 for ICU admission [17]. Although the discriminatory ability of the scores in both studies was moderately good, the high mortality of these patients when cared for in the wards suggests that triaging decisions to the ICU could potentially be done earlier. Interpretation is limited by the lack of data on patients for whom limitations of care were present, but this suggests a potential for future research in using scoring systems to consider ICU admission for patients who seem otherwise adequate for care on a regular ward.

Interventions to improve clinical outcomes

Evaluating outcomes has been used to study the uncertainty about the efficacy of an intervention. The use of steroids to treat community-acquired pneumonia has been suggested by some experts [18] but is still highly debatable [19]. In an attempt to improve our understanding of the benefits of steroids for pneumonia, a group from Spain conducted a randomized controlled trial of steroids for community-acquired pneumonia. Their results suggest an improvement in surrogate outcomes such as clinical resolution of pneumonia but do not allow generalization of their findings, because of a lack of a validated clinical outcome and imbalances in severity of illness [20]. Similarly, the use of steroids in neurotrauma is the subject of a large number of studies, and the largest study showed an increased risk of death associated with corticosteroids [21] but no obvious unwanted outcomes at 6 months. Further analysis of the original data by using methods that take into consideration the complete information contained in the 6-month outcome data demonstrates an association with steroids and long-term outcomes as well. This new information is important for two reasons: first, it improves clinicians' confidence that the use of steroids in this population is indeed detrimental, and, second, it shows that, for outcomes that contain information that is not binary, categorizing the outcome into binary variables may lead to loss of information and power in clinical trials [22].

Adverse events

Adverse events in the ICU are frequent; there is more than one incident per patient admission, and these are harmful for the patient 50% of the time [23]. Therefore, a key point in quality improvement and patient safety is to determine the clinical relevance of adverse events. One such example is the rate of unplanned extubations (UEs), which have been associated with increased morbidity and mortality [24]. Using a case control design, de Groot and colleagues [25], in The Netherlands, looked at the risk factors and outcomes after UE, and their results showed that 2% of all the mechanically ventilated patients had a UE and that almost half of them required re-intubation. The risk factors for a UE were a low Ramsay sedation score, male gender, length of ICU stay, and the use of midazolam. Interestingly, their results seem to refute the notion that patients with UE have worse outcomes, as the authors observed a lower mortality when compared with the patients on mechanical ventilation without UE (19% versus 32%) [25]; however, these results must be interpreted very cautiously as the methodological approach used had important limitations, including the lack of appropriate adjustment for a case control design and problems associated with the selection of controls not at risk for UE, such as comatose patients. Nevertheless, the

results question the use of UE as a quality indicator and concur with data from randomized trials of sedation interruption, in which UEs were not associated with worse outcomes [26].

Processes of care

Variability in the provision of critical care

Differences in the provision of services that are unrelated to diagnosis, severity of illness, or co-morbidities provide an alternative way to assess quality of care. For example, previous data have shown that, in Western countries, women are less likely than men to receive invasive treatment [27] and this might contribute to an excess mortality in women [28]. Shen and colleagues [29] analyzed the Taiwan National Health Insurance Research Database to look for differences in non-invasive ventilation for respiratory failure in female patients. After adjustment for potential confounders, women with respiratory failure were less likely than men to be admitted to intensive care (adjusted OR 0.77, 95% confidence interval [CI] 0.73 to 0.82) and less likely to use mechanical ventilation (OR 0.84, 95% CI 0.78 to 0.91). The authors did not observe differences in outcomes such as mortality and length of stay. However, in a single-center study from Germany, female gender was associated with mortality in the population of patients with sepsis (OR 1.9), but not in the overall population (OR 1.3), after adjustment for multiple confounders [30]. It is possible that these differences are related to residual confounding, to gender differences in response to critical illness, or to differences in clinical management.

Gender variability is also present in the provision of evidence-based practices. Han and colleagues [31] demonstrated that women with acute respiratory distress syndrome received lung-protective ventilation less frequently than men (46% versus 59%, $P < 0.001$). The authors were also able to provide a possible reason to help understand this relationship as this difference was no longer significant after adjusting for height [31]. What this means is that women do not receive less lung-protective ventilation because of their gender but because they are shorter.

Definitely, reasons for variability in the provision of care between genders merit further studies, including those that provide mechanisms to improve care. In the example above, encouraging the use of predicted body weight measurements on all patients would likely eliminate the gender disparity in the provision of lung-protective ventilation.

Variability also exists in the provision of rapid response teams (RRTs) and in delays for ICU admission. In spite of negative results from large cluster-randomized trials [32], RRTs are used in many different health-care systems. In fact, one may argue that a longer period of time is

required to observe the effects of the implementation of an RRT on clinical outcomes. A single-center report from the US suggests that RRT was effective in reducing mortality and out-of-ICU cardiac arrests 3 years after its implementation [33]. Obviously, the diversity in RRT effectiveness is related to the large variation in the composition of these teams and on their use, which may be for reasons other than the original intent to reduce cardiac arrests, such as avoiding ICU admissions, treating patients on the ward while waiting for the availability of an ICU bed, or helping with end-of-life discussions [34]. In a collaborative effort to identify delays in admission to an ICU after the activation of an RRT, Oglesby and colleagues [35] used an electronic system in 17 hospitals to measure the 'score to door time', a metric that measures the time to ICU admission after patients achieved a certain score that indicated the activation of RRT. This score combines two elements of RRT – the time to activation and the time to transfer to the ICU – and could help inform teams of whether delays are related to the afferent (the identification of the deteriorating patient) or the efferent (assessment of the patient and transfer to an ICU if required) limbs of the system. Their study does not provide the elements to determine whether delays are leading to harm or not, but they demonstrate again the variation in provision of critical care in different health-care settings and for different patients. British hospitals had longer 'score to door times', possibly a reflection of the availability of ICU beds in the UK [36], and this does not necessarily imply low-quality care, as these hospitals may use RRTs to provide critical care treatment while waiting for an ICU bed. However, some patient characteristics were also associated with delays, and these are more worrisome as they may be related to double standards of care. Particularly, higher APACHE II (Acute Physiology and Chronic Health Evaluation II) scores and younger age led to longer 'score to door times' [35]. It is not clear from their data whether the failure in these groups is related to the afferent or efferent limb.

In a related study, delays for admission in a single center in Brazil were modeled to predict mortality [37]. The authors observed an unadjusted increase in mortality of 13% in patients who had delays in admissions, which persisted after controlling for confounders, leading to a 1.5% increased risk of ICU death per hour of delay. Although there is always the possibility of residual confounding and selection bias, the authors were able to control for several important clinical confounders and also implemented a process of ICU admission that used a 'first come, first served' basis, which should help decrease selection bias [37]. Variability of access to care and outcomes because of health insurance status may point toward areas for policy-making at national levels.

However, these are very difficult to sort out as admissions may be confounded by the different types of service provided by different types of insurance (for example, patients with private insurance may be admitted more frequently for elective procedures than patients without private insurance) and by diverse socioeconomic factors, such as lack of access to preventive measures (vaccination) or poor living conditions. Nevertheless, O'Brien and colleagues [38] tried to better understand this relationship in the US and observed a higher adjusted rate of sepsis-associated admissions among patients without private insurance and a higher sepsis-related mortality for the uninsured patients. As in most studies using administrative databases, it is likely that there may be potential residual confounding and differential biases in coding which could potentially explain these differences, but this raises the importance of investigating sepsis mortality in difference insurance types with more scrutiny.

Decision-making in the ICU

Decision-making by ICU clinicians involves teamwork, verbal communication, and information-gathering. This is a crucial process for task coordination and performance in ICUs [39]. Given the acuity of critically ill patients, several *ad hoc* decisions are necessary to support patient care and work flow during the management of daily ICU activities. Even though the management of ICU activities is quite well delineated by international consensus guidelines, we know very little about the content of the real clinical decision-making that supports daily activities by the inter-professional team. Lundgren-Laine and colleagues [40] conducted an important qualitative study to better understand the types of decisions made by staff in ICUs. They observed that nurses and shift leaders made a large number of decisions that were focused on processes, such as dealing with human and material resources, but that intensivists tended to focus their decisions on situations, such as gathering patient information, and deciding on special treatments and diagnostic strategies. Most of the decisions were not isolated but bundled to deal with specific problems; therefore, they required a large amount of communication, information-gathering, and situation awareness by all members in the team [40]. Studies such as this one may help inform the design of information and communication systems for busy units, such as electronic dashboards and automated text-based alerts.

An interesting report from The Netherlands demonstrates how the process of decision-making for organ donation has changed over the past two decades [41]. There were policy changes such as the implementation of an optional donor registration and the introduction of

donation after circulatory arrest, and these two events possibly led to a move toward more discussions with the family before the confirmation of brain death occurred. Unfortunately, the authors do not have outcomes, such as rates of refusal or family satisfaction, to elucidate any possible effects of this change in practice.

Postoperative goal-directed therapy

For decades, intensivists have been trying to demonstrate that hemodynamic goal-directed therapy (GDT) can improve mortality for high-risk surgical patients [42]. Unfortunately, a large randomized controlled trial does not support this practice [43]; therefore, investigators started focusing on the benefits of GDT in surrogate outcomes such as postoperative renal [44] and gastrointestinal [45] complications. The same group then performed a systematic review with meta-analysis to answer the question of whether GDT can decrease nosocomial infections after major surgery [46]. Twenty-six randomized controlled trials with a combined total of 4,188 patients were included. Perioperative GDT significantly reduced surgical site infections (OR 0.58), pneumonia (OR 0.71), and urinary tract infections (OR 0.44). However, it is concerning that the largest multicenter study was not significant for any of these end-points. Furthermore, this meta-analysis combines surgeries as diverse as cardiac surgery and colorectal surgery and does not explore the possible interactions between the intervention and these different populations. Modern postoperative care is, in fact, leaning toward a more restrictive approach to fluids in the postoperative period while providing GDT in the intraoperative period [47,48].

Knowledge translation

Failure to adhere to evidence-based best practices is frequent in critically ill patients [49,50]. Data indicate that 30% to 50% of patients do not get recommended care and that 20% to 30% of patients receive unnecessary interventions [49,51]. However, implementing best practices is difficult, and the traditional methods of best-practice implementation, such as education, reminders, and audit and feedback, are, at best, modestly effective [52]. Therefore, it is not a surprise that a well-conducted and large multicenter collaborative study to improve evidence-based treatment of patients with nosocomial pneumonia, including ventilator-associated pneumonia (VAP), was effective but still left a large gap in quality [53]. A group of four American institutions developed and implemented a critical pathway for the treatment of patients with nosocomial pneumonia. The institutions included customization of antibiotic choice at the institutional level to improve compliance and provided an unspecified educational bundle. They were able to improve compliance with recommended empiric

treatment from 30.7% to 43.7% ($P = 0.01$), and this means that still over 50% of patients did not receive the recommended therapy [53]. This study is yet another call for additional robust and generalizable interventions to lead to effective behavior modification of clinicians.

One of the most striking examples of lack of adoption of an evidence-based therapy is the use of selective digestive decontamination (SDD) to prevent VAP. In spite of a large number of positive studies [54], many physicians are reluctant to adopt this intervention, owing to concerns with microbiological resistance. Another potential concern is the possibility of an increased rate of VAPs in the control groups of the SDD studies because of cross-colonization between study patients and control patients. Hurley [55] investigated this by using an ingenious method of establishing a benchmark of VAP from observational studies and then looking at the VAP rates of control groups in both SDD studies and in studies of non-antimicrobial strategies to prevent VAP. Findings are quite interesting as the control groups of non-SDD studies had similar rates of VAP when compared with the benchmark (17.5 versus 22 out of 100 patients), but the control groups from the SDD studies had a higher rate of VAPs than the benchmark (42 versus 22 out of 100 patients) [55]. This association did not seem to be confounded by mode of diagnosis, trauma admissions, or proportion of ventilated patients. The possible explanations include cross-colonization of control patients in the SDD studies but also the possibility of ascertainment bias in the diagnosis of VAP.

ICU structure

The structure of an ICU, which may involve elements such as architecture, resource availability, the model of care, and staffing, also influences outcomes. While there are recommendations from societies and government on the requirements, many of these are not based on evidence. Some papers from *Critical Care* last year help understand structural elements of an ICU in better detail.

In a naturally occurring experiment of changes in ICU design in Israel, Levin and colleagues [56] were able to demonstrate a statistically significant decrease in the acquisition of antibiotic-resistant organisms (5% versus 18%) and an increase in compliance with hand hygiene (58% versus 35%) when an ICU was re-built with single-patient rooms. Their results are quite robust as the main comparisons were performed with a concurrent control that remained unchanged and had a similar case mix of patients.

While the above example demonstrates further refinements in improving ICU structure, a report from Africa discusses more basic barriers to providing high-quality critical care. In a continent-wide survey of resource availability to implement the Surviving Sepsis Campaign,

the authors recorded unavailability of emergency rooms (14.5%) and ICUs (26.2%) as important barriers to treat sepsis. Furthermore, only 1.5% of respondents would have access to implement the guidelines in their entirety [57].

Abbreviations

AUC, area under the curve; CI, confidence interval; GDT, goal-directed therapy; ICU, intensive care unit; OR, odds ratio; PMV, prolonged mechanical ventilation; PTSD, post-traumatic stress disorder; RRT, rapid response team; SDD, selective digestive decontamination; UE, unplanned extubation; VAP, ventilator-associated pneumonia.

Competing interests

The authors declare that they have no competing interests.

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