Patient Safety, Quality of Care, and Knowledge Translation in the Intensive Care Unit

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A large gap exists between the completion of clinical research demonstrating the benefit of new treatment interventions and improved patient outcomes resulting from implementation of these interventions as part of routine clinical practice. This gap clearly affects patient safety and quality of care. Knowledge translation is important for addressing this gap, but evaluation of the most appropriate and effective knowledge translation methods is still ongoing. Through describing one model for knowledge translation and an example of its implementation, insights can be gained into systematic methods for advancing the implementation of evidence-based interventions to improve safety, quality, and patient outcomes. *Key words: knowledge translation; patient safety; quality of healthcare; evidence-based practice; outcome assessment (healthcare); respiration, artificial; acute respiratory distress syndrome*. [Respir Care 2010;55(7):922–928. © 2010 Daedalus Enterprises]

Introduction

Patient safety, quality of care, and knowledge translation are issues of growing importance in the intensive care unit (ICU) setting. I will address this topic in 4 sections: (1) the nature of these issues within medicine, and specifically within critical care, (2) the use of knowledge trans-

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lation as an effort to improve safety and quality, (3) examples of ICU-focused knowledge translation projects, and (4) a model for undertaking knowledge translation in your own clinical practice setting.

The Nature of the Problem

First I will provide some brief general remarks regarding safety and quality, and related problems within medicine, and then discuss these issues in greater detail within the context of critical care medicine.

Safety and Quality

The nature of patient safety and quality problems within healthcare is very broad.[1] Relevant issues range from improving interdisciplinary teamwork and communication to reducing risks from rare events. However, in thinking about safety and quality, I will focus on errors of omission, in particular the failure to ensure that patients receive recommended medical care that is supported by high-quality clinical research evidence. This type of safety and quality problem can be effectively addressed with knowledge translation tools.

The Overall Problem Within Medicine

With respect to the safety and quality problem within the United States, I want to highlight 2 specific points regarding the general field of medicine, before discussing critical care medicine in greater detail. First, in the United States, one prominent study indicates that patients receive only 50% of recommended medical care.[2] Second, although difficult to fully analyze, it appears that only 14% of new scientific discoveries make it into routine clinical practice, and this process requires, on average, 17 years to occur.[3] I believe that these 2 statements highlight that the American biomedical research enterprise is better at discovering new treatments than in understanding how to effectively deliver existing treatments. This situation is created, in part, by the system of funding for biomedical research, since among all United States federal and foundation funding, only 1.5% is directed toward all of health services research, which includes research directed at safety, quality, and knowledge translation.[4]

The Problem Within Critical Care Medicine

After this brief background, it is important to consider how critical care medicine might fare with respect to safety and quality issues. The Critical Care Safety Study is an instructive example.[5] This research was a one-year prospective study conducted in one medical ICU and one coronary care unit at an urban, academic, tertiary-care hospital. The study included almost 400 patients and 1,500 patient days of data, and discovered that 20% of patients had an adverse event, of which almost 50% were preventable. There were 36 preventable adverse events per 1,000 patient days. This study helps us understand that adverse events in the ICU are common, serious, and preventable. Moreover, given similarities in the type of safety events, the related harm, and the underlying system factors between medical and surgical patients,[6] I believe these results from the Critical Care Safety Study are generalizable beyond the medical ICU and coronary care unit to other ICU settings.

Why are adverse events common and serious in the ICU? The ICU setting creates the "perfect storm" for medical errors, particularly errors of omission. I say this because the ICU is a complex environment in which patients have multisystem disease and little physiological reserve. Moreover, we know that human error and the fallibility of human memory are made worse by factors such as stress, fatigue, noise, time pressures, interruptions, and distractions.[7,8] Each of these factors is commonly experienced in the ICU setting.

To exemplify safety, quality, and knowledge translation issues in the ICU, I want to focus on lung-protective ventilation, via lower tidal volume, for patients with acute lung injury/acute respiratory distress syndrome (ALI/ARDS). My research group evaluated this issue in 9 ICUs within 3 ARDS Network-affiliated teaching hospitals in Baltimore, Maryland. Among 202 patients prospectively diagnosed with ALI, on the day after diagnosis (day 1), 54% received tidal volume in excess of 6.5 mL/kg of predicted body weight (PBW).[9] Using a less strict definition of lower-tidal-volume ventilation, 19% of patients received tidal volume greater than 8.5 mg/kg PBW. There was no significant improvement in these findings by day 3 and day 5 after ALI. We hypothesized that specific patient factors may be associated with use of lower tidal volume, but of 16 potentially relevant patient factors, only one (serum bicarbonate concentration) was associated with lower-tidal-volume ventilation. However, among potentially relevant ICU organizational factors, the use of a written protocol for delivery of lower-tidal-volume ventilation was strongly associated with this evidence-based practice, with an odds ratio of 6.0 (95% CI 1.3–27.2).

Another study at a single teaching hospital in Toronto, Canada, demonstrated similar results when evaluating the use of evidence-based care among 100 patients in a single medical-surgical-trauma ICU.[10] The range for the proportion of eligible patients prescribed evidence-based care was wide, from 8% for sedation interruption to 95% for thromboembolism prophylaxis. Among patients with ALI, 54% received lower-tidal-volume ventilation (defined as < 8 mL/kg of actual body weight). Similar to the prior

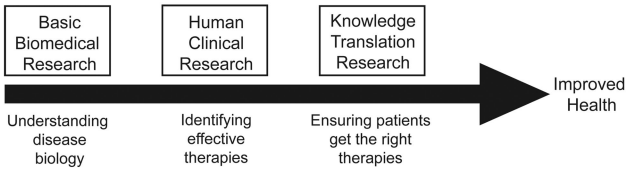

Fig. 1. The Biomedical Research Continuum. The arrow illustrates the focus of knowledge translation research which helps ensure that proven therapies from "human clinical research" are used safely and effectively to reach the goal of improved health for patients.

study, the use of standard order sets was positively associated with prescription of evidence-based care.

Finally, a large study by the German Sepsis Network allows evaluation of this issue outside of the North American setting. This study was conducted as a 1-day representative random sample involving 454 ICUs, representing 22% of all ICUs in Germany. Among 152 patients with ALI, 80% received $>$ 8 mL/kg PBW, while only 2.6% received $\leq$ 6 mL/kg PBW. Given this low adherence to evidence-based practice, it is particularly interesting to note that, when surveyed, 80% of ICU directors perceived that they were adherent to lower-tidal-volume ventilation for ALI patients. Hence, there is clearly a need for improvement with safety and quality issues within critical care medicine.

Knowledge Translation to Improve Problems With Safety and Quality

At this point I presume everyone appreciates the large gap in the "biomedical research continuum" that aims to move basic science research discoveries into improved patient health (Fig. 1). Knowledge translation efforts can help fill this gap by focusing on methods to ensure that therapies proven effective within human clinical research studies are actually used, safely and effectively, in routine clinical practice. The nomenclature surrounding knowledge translation is not fully refined, with these efforts being referred to by many other names, including "T2", translating research into practice (TRIP), implementation science, dissemination research, health services research, knowledge transfer, and quality improvement research.[4,11] I will continue to use the term "knowledge translation" to refer to this concept.

Understanding the most effective knowledge translation methods for changing routine practice and embracing clinical research findings is still evolving. There is relatively little experimental testing of knowledge translation methods, but systematic comparisons of knowledge translation methods and study outcomes have helped improve our understanding of the potential effectiveness of different methods.[12,13] Relatively weak methods for knowledge translation include passive education, via continuing education or creation of clinical practice guidelines. There is variable or moderate evidence supporting knowledge translation methods that involve economic incentives, quality improvement collaboratives,[14,15] local opinion leaders, or audit and feedback.

Audit and feedback is a particularly popular knowledge translation method, where one measures ("audits") routine clinical practice regarding implementation of a specific evidence-based practice, as done in the 3 example studies outlined in the prior section. These findings are then given as "feedback" to clinicians as a means to help motivate improvement in clinical practice. As a knowledge translation method, audit and feedback appears to be more effective in several specific circumstances, such as when: (1) done with high intensity, (2) there is low adherence to evidence-based practice at baseline, and (3) the audit reports are perceived to be credible by the clinicians receiving them.[13,16,17]

Finally, the use of checklists and providing timely reminders to clinicians regarding evidence-based care for appropriate patients may be a strong method for knowledge translation. However, ALI research within the ICU setting has demonstrated that even this methodology is not fail-safe.[18] Rather than reliance on just one or two methods, a multi-faceted knowledge translation approach, combining several of these strategies within a particular project, may lead to better results.

Examples of Knowledge Translation Studies in the ICU

To provide tangible examples of knowledge translation projects and methods, I want to outline 2 published knowledge translation projects within the field of critical care. The first is a national project to improve under-utilization of evidence-based practices for patients with sepsis. A national before-and-after study involving 59 ICUs in Spain was conducted using education and teamwork methods for achieving greater implementation of the Surviving Sepsis Campaign's clinical practice guidelines.[19] The study did not emphasize customizing the knowledge translation intervention to local ICU culture and did not involve regular audit and feedback. The study found that adherence to the clinical practice guidelines was low at baseline but significantly increased in the post-knowledge translation study period, with reduced mortality, compared to the pre-implementation baseline period (39.7% vs 44%, $P = .04$). At one-year follow-up, adherence to some aspects of the guidelines had declined, but the mortality benefit appeared to be sustained. The study was remarkable for demonstrating implementation of a knowledge translation intervention on a nationwide basis and for empirically demonstrating that creation of guidelines alone is not enough to ensure im-

plementation and improved patient outcomes. With stronger knowledge translation methods, perhaps even larger and more sustained benefits may have been achieved in that project.

A second example of a large-scale knowledge translation project focused on reducing catheter-related bloodstream infections in a quality-improvement collaborative of 103 ICUs located predominantly in Michigan.[20] This is a study that I was involved in. This project focused on improving adherence to interventions from the Centers for Disease Control's clinical practice guidelines for prevention of catheter-related bloodstream infections.[21] To assist with implementation of these evidence-based practices, a number of important issues were focused upon in this knowledge translation project, including convenience, reminders, and checklists. First, among busy ICU clinicians, making adherence to evidence-based practice convenient and easy can help with creating a positive change in routine practice. Specifically, to assist with having all the necessary supplies for maximally sterile insertion of the central venous catheter, these supplies were stored on a "central line cart" that could be moved to the patient's room at the time of catheter insertion. Second, a written daily goals sheet,[22] used during bedside rounds to improve communication among the multidisciplinary ICU team, included a reminder to remove any unnecessary central venous catheters. Finally, a checklist, completed by a clinician assisting with the catheter insertion, was created to help ensure that appropriate evidence-based practices were being implemented, in the correct order, during non-emergency catheter insertions. Audit and feedback of monthly catheter-related bloodstream infection rates was also part of the knowledge translation methods for this project.

With these methods, this state-wide project collected data over an 18-month period after implementation of the multi-faceted intervention, observing greater than 1,000 ICU months and 375,000 catheter days of data. Over the 18-month period, the average catheter-related bloodstream infection rate decreased from a pre-intervention baseline rate of 7.7 per 1,000 catheter days to 1.4 at 16–18 months after implementation.[20] The rate of reduction of catheter-related bloodstream infection rate continued to improve throughout the 18-month follow-up period. Moreover, after completion of the project, the reduced catheter-related bloodstream infection rate was sustained over an additional 18-month follow-up period, until 3 years after implementation.[23]

A Model for Undertaking Knowledge Translation

While these prior examples do not directly deal with respiratory care, to have a practical take-home message from this lecture, I want to share with you a model for conducting knowledge translation that can be applied in your own clinical practice setting (Fig. 2).[24] I am presenting a model that I have the most experience with, but other models exist and can be used.[11,25-27] As I review this model, I suggest that you think of a specific problem requiring improvement in your own clinical practice setting so that the practical application of this approach may become clearer to you. To assist with understanding the practical implementation of this model, throughout my discussion I will apply this model to the challenge of improving the use of lower-tidal-volume ventilation for patients with ALI.

Overall Concepts

Two concepts are important considerations throughout the entire knowledge translation process. First, it is key to envision the problem requiring improvement within the larger overall healthcare system. Each problem occurs within the context of our complex healthcare systems, where there are many interdependencies between processes of care. Second, as a function of our healthcare system, solutions to clinical practice problems require collaboration of a multidisciplinary team that includes all stakeholders impacted or affecting the problem and/or the solution. These concepts should be considered in both the planning and the implementation of knowledge translation in your local clinical practice environment.

Step 1: Summarize the Evidence

To improve a patient outcome, it is important to identify which healthcare interventions are associated with the outcome. Among any long list of interventions, consideration should be given to selecting a small number of interventions that have the largest potential benefit for improving the outcome, and the lowest barriers to implementation. Moreover, for disseminating these interventions, they should be phrased as a behavior to ensure that the activity required of the clinician is clear.

Using the example of knowledge translation to improve implementation of lower-tidal-volume ventilation for ALI patients, a search of the literature will find an existing systematic review evaluating ventilatory management strategies for ALI.[28] This review has already systematically searched, evaluated, and summarized the evidence and concluded that "volume- and pressure-limited mechanical ventilation strategies should be used in managing adult acute lung injury and acute respiratory distress patients." This recommendation is largely based upon a large, multi-site randomized controlled trial of lower versus higher tidal volume for ALI patients, conducted by the ARDS Network, which demonstrated a substantial reduction in mortality (31% vs 40%, $P = .007$) with the lower-tidal-volume ventilation strategy.[29]

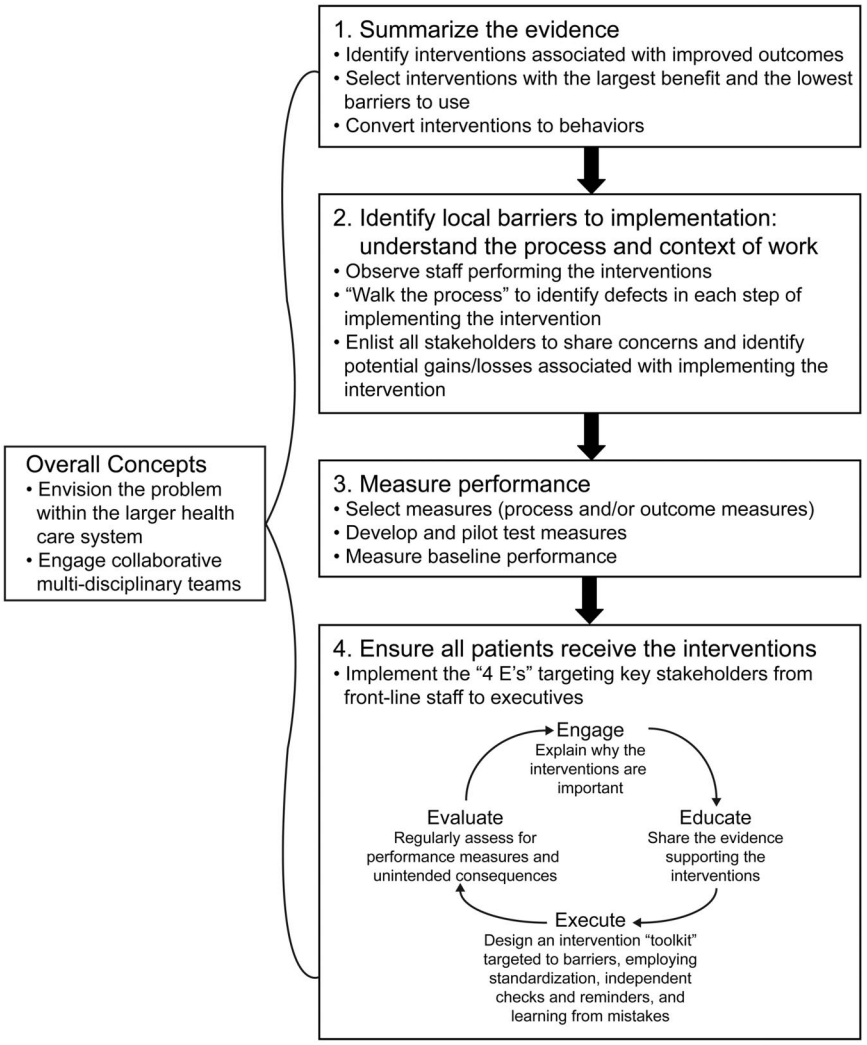

Fig. 2. A summary of one model for conducting knowledge translation to increase the use of evidence-based care in routine clinical practice. (Adapted from Reference 24, with permission.)

Step 2: Identify Local Barriers to Implementation

In order to change clinical practice and improve utilization of evidence-based care, it is key to identify the unique barriers to implementation in your own practice setting. Certain barriers will be unique to each setting and must be systematically uncovered. To understand such barriers it is essential that your multidisciplinary knowledge translation group understands the process and context of the clinical practice. This understanding can be gained through observing staff actually performing the intervention and thinking through each step of the process to identify areas that may impede implementation of evidence-based practice. It is vital for all affected stakeholders to assist with identifying barriers in order to fully understand what each party may gain or lose through a change in practice. As described in detail elsewhere,[30] practical tools can assist with this process of barrier identification.

Within my own hospital we systematically evaluated some of the barriers to use of lower-tidal-volume ventilation for ALI patients via a formal survey of respiratory therapists, nurses, and physicians working in 3 ICUs.[31] The results of our survey demonstrated that clinicians' perceived barriers varied by clinical discipline and years of work experience. Moreover, specific barriers regarding attitudes, behaviors, and practices were discovered that could assist with the design of specific knowledge translation strategies to overcome them.

Step 3: Measure Performance

Understanding measures of performance relevant to the knowledge translation area is important for monitoring

improvement. Measures may be related to specific patient outcomes (eg, mortality rate for ALI patients) or processes of care (eg, average tidal volume, in mL/kg PBW, for ALI patients). Performance measures must have the following characteristics to be successful:

- Relevance to the knowledge translation project
- Validity as a measure of the underlying problem
- Reliability when repeatedly measured
- Feasibility for measurement as part of routine practice

It is key to pilot-test proposed performance measures to evaluate these characteristics and to ensure that the measure(s) have credibility with bedside clinicians who will receive these results as part of audit and feedback. Once suitable measure(s) have been selected, baseline performance using those measure(s) should be obtained in order to inform the subsequent steps of the knowledge translation process.

Step 4: Ensure That Patients Receive the Interventions

After completion of the preceding 3 steps, your multidisciplinary group can focus on methods to ensure that patients actually receive the intervention of interest in your knowledge translation project. We propose a simple "4 E's" model as part of our knowledge translation model: Engage, Educate, Execute, and Evaluate.

First, it is key to actually "Engage" all the responsible stakeholders in the knowledge translation project so that they fully understand why change is important. Engagement can be done via many methods, such as use of patient case studies, anecdotes, interesting and recent publications, local data, or motivational guest speakers.

Only once stakeholders are engaged, can attention be directed to the "Educate" portion of this process. When educating, it is critical to share the clinical research evidence supporting the intervention(s) being undertaken in the knowledge translation project. However, this process of education needs to be easily accessible to busy clinicians, and can include, for example, brief (eg, half page) summaries of relevant studies that can be given to staff and posted on bulletin boards for quick and convenient review.

"Execution" involves actual implementation of the interventions, using the various knowledge translation methods previously outlined. In general, a "toolkit" for implementation of evidence-based care will be more likely to succeed if it includes features that address issues of convenience or simplification, standardization, reminders, and checklists. Moreover, execution of the intervention should include learning from mistakes, which can be very motivating when conducted as a constructive part of efforts for continuous improvement.

Finally, "Evaluation" should be carried out throughout the ongoing knowledge translation project, using the performance measures developed in Step 3. In addition, evaluating for potential unintended consequences of the interventions is key to ensure that added attention to one area has not resulted in new deficits in another area. The "4 E's" process, as depicted in Figure 2, is an iterative process so that the evaluation results are acted upon, in an effort to further improve results, by additional focus on engagement, education, and execution related to the knowledge translation project.

Conclusions

In conclusion, there is clearly a large gap between clinical research findings and implementation of these findings as part of routine clinical practice. This gap clearly affects patient safety and quality of care within the field of respiratory care, critical care, and all healthcare services. Knowledge translation is crucial to bridging this gap, but evaluation of the most appropriate and effective knowledge translation methods is still ongoing. Through reviewing one model for knowledge translation, my hope is that you will return to your clinical practice setting and become empowered to effectively "translate what we know into what we do."

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