Translating Evidence Into Practice

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Summary

Appropriately designed and conducted research is necessary for improving patient care and optimizing health outcomes, but access to best evidence is not enough to make these things happen. In respiratory care, as in other fields, patients do not benefit as much as they should from research findings and evidence-based practice guidelines. Current standards for the diagnosis, staging, and management of chronic obstructive pulmonary disease are based in large part on the results of spirometry, yet most patients carrying this diagnosis have not had this test performed. Despite compelling evidence that it saves lives, reduces complications, and decreases costs in acute respiratory failure complicating chronic obstructive pulmonary disease, noninvasive ventilation is not used in a large proportion of such cases. Lung-protective ventilation for acute lung injury and the acute respiratory distress syndrome also increases survival, decreases complications, and is cost-effective, yet many patients who stand to benefit do not receive it. Clinicians may not be aware of practice guidelines or be familiar with their recommendations; they may not agree with the recommendations, or have insufficient expectation that management according to the guideline will work; they may consider the guideline too complicated or difficult to use in their own practices; patient-related factors may interfere; and changing established practice is often difficult. Overcoming these and other barriers to best practice is the focus of knowledge translation, which recognizes the need for involvement of every aspect of health care and seeks to integrate them effectively. This paper discusses the challenges faced by knowledge translation, provides examples of its successful application in respiratory care, and summarizes what needs to be done if the potential benefits of available evidence are to be realized for both individual patients and the health care system as a whole. *Key words: knowledge translation, evidence-based medicine, practice guidelines, barriers, cost-effectiveness, outcomes, chronic obstructive pulmonary disease, COPD, asthma, acute lung injury, mechanical ventilation, lung-protective ventilation.* [Respir Care 2009;54(10):1386–1401. © 2009 Daedalus Enterprises]

Introduction

Research seeks to answer questions about disease and its treatment, as well as to increase our understanding of natural phenomena. While this process is worthwhile in and of itself, in health care, research has another main purpose—to benefit patients. In this context its goals are to prevent and cure disease, to reduce morbidity, to relieve suffering, to improve quality of life, and to prevent adverse effects of both illness and its treatments. In addition, the pursuit of these goals in today's world must accommodate concomitant mandates for cost-effectiveness and the wise use of resources.

Evidence-based medicine is the conscientious, explicit, and judicious use of current best evidence in patient management.[1,2] However, the notion that better patient care will follow naturally from best evidence (Fig. 1) is wrong: when it comes to improving the care of patients and achieving outcomes that matter to them, evidence is necessary but far from sufficient. Asking the right questions, carrying out the research correctly, and disseminating the findings via the medical literature do not complete the process. Nor does a successful search of the literature and an accurate interpretation of the relevant articles—as discussed in the other articles in this series[3-6]—guarantee that a patient's clinical problem will be helped.

This paper illustrates how we know that evidence is not enough by means of several familiar examples in respiratory care. It discusses some of the barriers that stand in the way of best practice, even when practical guidelines based on best evidence are available, and introduces the topic of knowledge translation (KT), which seeks to overcome these barriers. Once KT is defined and described, some further examples illustrate how its principles can be applied effectively. The article concludes with a brief discussion of what needs to happen, from the health systems level down to that of the individual practitioner, in order for the potential advances of both research and KT to occur in respiratory care.

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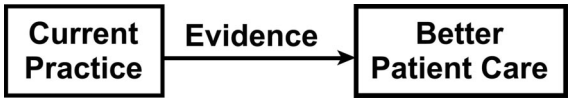

Fig. 1. Evidence-based medicine deals with the use of current best evidence in clinical decision making and other aspects of patient care. However, the assumption that simply having the evidence will improve patient care, as shown schematically here, is unfortunately incorrect.

Evidence Is Not Enough

Even after publication of high-level evidence in the peer-reviewed scientific literature, experience in many areas of health care has shown that the spread of the new knowledge to practitioners, and its application in actual patient care, has been frustratingly slow. The classic example, cited because it was among the first to be extensively studied and also because the evidence involved is so compelling, is that of thrombolytic therapy in acute myocardial infarction.[7,8] The first randomized controlled trial showing that this therapy was life-saving was carried out in the late 1950s. Ten such trials were published over the next decade, and meta-analysis of the findings in the more than 2,500 patients involved demonstrated a positive therapeutic effect, with a 95% confidence interval that did not cross the neutral value of 1.

Despite this compelling evidence, many more such trials were subsequently carried out, and a series of cumulative meta-analyses demonstrated a consistent, life-saving effect, with narrower and narrower confidence limits. However, it was not until more than 40,000 patients had been studied (many of them receiving placebo treatment) that consensus recommendations for thrombolytic therapy for acute myocardial infarction were published. Subsequent studies showed that actual implementation of the therapy at the hospital level lagged even further behind. Thus, the period between the availability of best evidence and the widespread application of that evidence in patient care was way too long, and during that interval many patients were unable to benefit from the knowledge that had been gained through research.

There are many similar examples, in the management of a wide range of medical conditions. The widespread failure to implement best practice even in the presence of high-level evidence received extensive publicity following publication of the Institute of Medicine's report, *Crossing the Quality Chasm*, which provided extensive documentation of the problem in all areas of the United States healthcare system.[9] Figure 2 illustrates the concept of the quality chasm, emphasizing the importance to clinicians and patients alike that it be bridged if the promise of evidence-based medicine is to be realized.

One contributor to the difference between what the evidence says should be done and what actually happens is

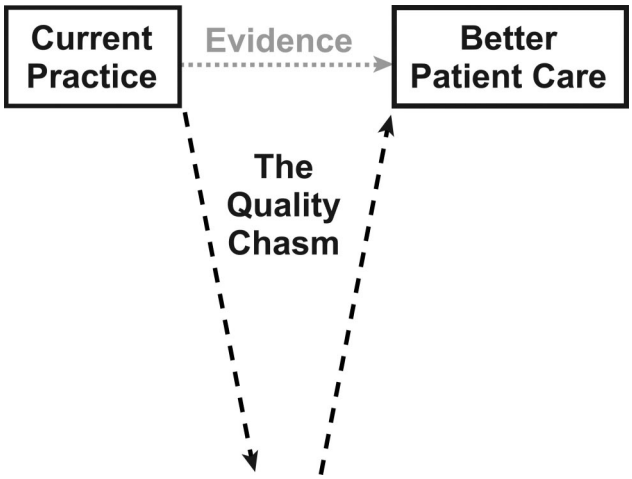

Fig. 2. The gap between current practice and what could be achieved by application of best available evidence has been called the "Quality Chasm."

Table 1. Important Distinctions Between Efficacy (as Demonstrated in Clinical Trials) and Clinical Effectiveness (as Experienced in Everyday Practice)

Efficacy	Effectiveness
Results under research conditions	Results obtained in real-world, everyday clinical practice
Patients carefully selected	Unselected patients
No comorbidities or other interfering problems	Many patients have other medical conditions and other problems that complicate management
Rigidly controlled protocol for management and monitoring	Techniques and protocol may or may not match what was done in the clinical trial
Overseen by investigators and dedicated research staff	No special oversight in terms of the intervention

(From Reference 10.)

the real-world distinction between efficacy and clinical effectiveness (Table 1).[10] Clinical trials demonstrate efficacy. That is, under carefully controlled circumstances and in cases that are as nearly ideal as possible, they show the effect of the therapy in question. In contrast, clinical effectiveness describes what happens when that therapy is applied in everyday practice. With the latter there are many more variables, and many potential reasons why results obtained in the research setting may not be the same.

There can also be important differences between what clinicians say they do—when asked, for example, in a questionnaire-based study—and what they actually do when directly observed.[10] Studies carried out in a variety of clinical settings have documented this discrepancy. One relevant example is routine ventilator checks, the patient-ventilator system assessments carried out at prescribed intervals by respiratory therapists during mechanical ventilation. As part of a community-based study of the incidence and outcomes of acute lung injury (ALI),[11] Akhtar and colleagues looked at how ventilator checks were done at 17 adult acute-care hospitals in King County, Washington.[12] As standards for what should be included in such checks, they used the American Association for Respiratory Care's clinical practice guideline for routine ventilator checks,[13] plus several other measures integral to lung-protective ventilation (LPV),[14] such as end-inspiratory plateau pressure and static compliance.[12] They examined blank flow sheets for intensive care unit (ICU) charting for the presence of these items, and also interviewed respiratory therapy department managers about current practice. In addition, they reviewed charts of patients with ALI or the acute respiratory distress syndrome (ARDS) to see whether the items were actually charted.

Despite the presence of a practice guideline, Akhtar and associates found dramatic variations in both intended and actual charting for routine ventilator checks. Figure 3 illustrates the variation in the contents of the respiratory therapy charting sheets in the 17 hospitals for 30 of the 57 items examined.[12] End-inspiratory plateau pressure, intrinsic positive end-expiratory pressure (auto-PEEP), and static compliance were present on the flow sheets of 13, 8, and 10 hospitals, respectively. The investigators found discrepancies between what the department managers said was routinely measured and charted and what was actually found in the patients' records, as illustrated for auto-PEEP, plateau pressure, and static compliance in Figure 4.[12]

This study can be criticized for its use of a practice guideline that was a decade old at the time it was carried out, and that still needs to be updated. That guideline was also not strictly evidence-based, weakening the argument that practice deviated from best practice at the studied hospitals. Nonetheless, given the wide variation in both intended and actual practice in the hospitals studied, it is tempting to surmise that there was also some variation in the quality of care delivered. There are numerous other settings in this field that illustrate the quality chasm between evidence and actual patient care, of which the following three are offered as examples.

Diagnosis and Management of Chronic Obstructive Pulmonary Disease

Although there is increasing evidence that chronic obstructive pulmonary disease (COPD) is not just a disorder of the airways, all current practice guidelines recommend the objective assessment of pulmonary function—specifically the performance of spirometry—as a necessary component in making the diagnosis and classifying disease severity.[15] The most widely used guidelines in North America, all of them evidence-based, rely on the forced expi-

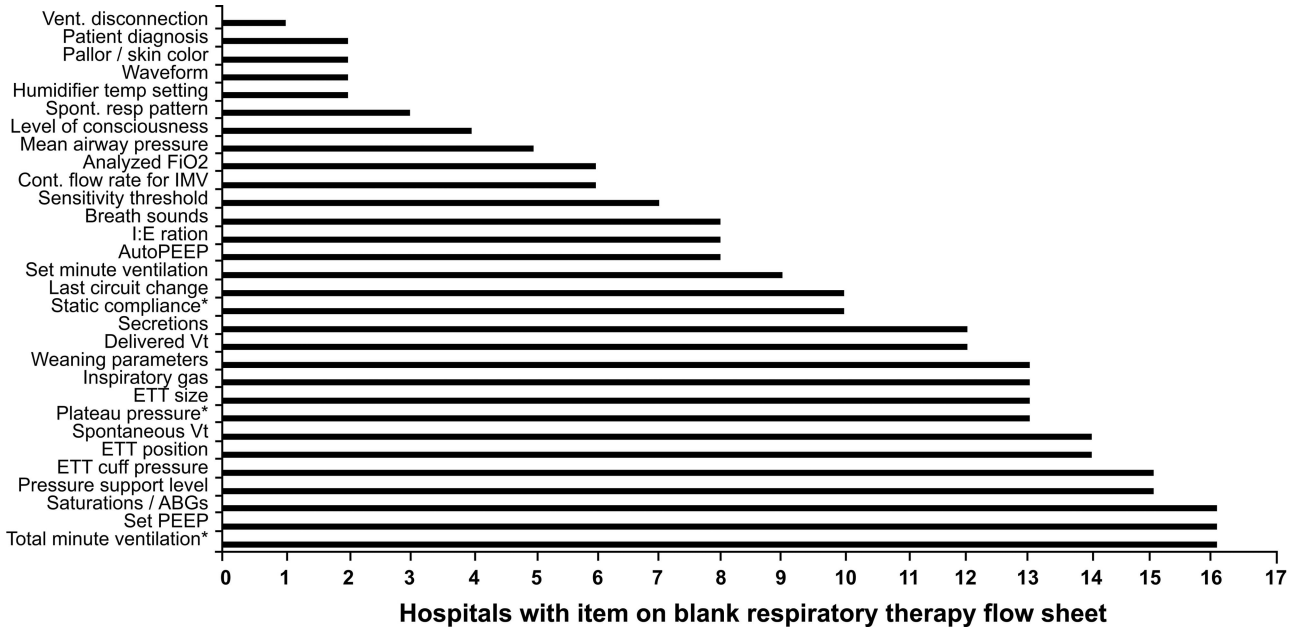

Fig. 3. Variability of blank respiratory therapy flow sheets for charting routine ventilator checks in 17 adult acute-care hospitals in King County, Washington, showing 30 of the items examined that were present on at least one flow sheet but not all of them. All items are from the American Association for Respiratory Care's clinical practice guideline for ventilator checks,[13] except for the 3 indicated by asterisks, which were added because of their importance for lung-protective ventilation.[14] F_{IO_2} = fraction of inspired oxygen. IMV = intermittent mandatory ventilation. I:E = inspiratory:expiratory. AutoPEEP = intrinsic positive end-expiratory pressure. V_T = tidal volume. ETT = endotracheal tube. ABG = arterial blood gas. (From Reference 12, with permission.)

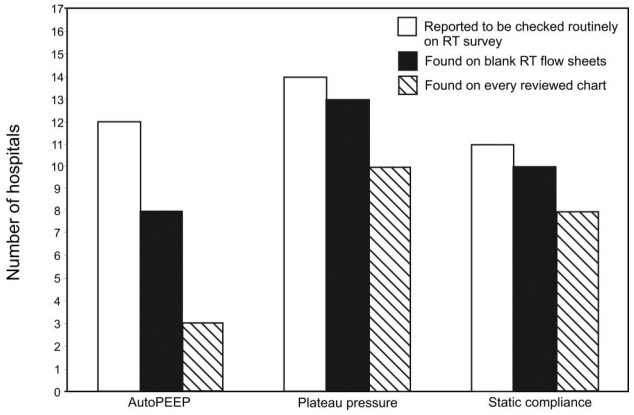

Fig. 4. Inconsistencies between reported and actual documentation practice with respect to 3 important elements of routine ventilator checks, from a study of management of acute lung injury and the acute respiratory distress syndrome at 17 adult acute-care hospitals in one United States county. AutoPEEP = intrinsic positive end-expiratory pressure. RT = respiratory therapy. (Adapted from Reference 12, with permission.)

ratory volume in the first second (FEV_1) and its relationship to the forced vital capacity (FVC) for confirming the diagnosis of COPD, and base their recommendations for therapy at least in part on the severity of FEV_1 impairment.[16-19] Yet there is considerable evidence that many patients—probably most of them—labeled as having COPD and prescribed treatments for it have never had spirometry. In that context, the likelihood that most of them are receiving optimum care, for a disease they truly have and tailored to its severity in accordance with current evidence, seems small.

Damarla and associates reviewed the records of all patients admitted to a tertiary referral hospital in Boston with the diagnoses of COPD and/or congestive heart failure during a 6-month period to see whether they had undergone spirometry or echocardiography to confirm the diagnosis within the previous 8 years.[20] They found that only 173 of 553 patients (31%) diagnosed with COPD had had spirometry, whereas 619 of 789 patients (78%) who carried the diagnosis of congestive heart failure had had echocardiography. Only 35% of patients with acute respiratory failure ascribed to COPD had had their lung function measured. Furthermore, of those "COPD" patients who had undergone pulmonary function testing, 30% actually had normal findings or results indicating the presence of a restrictive rather than an obstructive process.

Thus, a large proportion of patients given the diagnosis of COPD by their physicians have not had the diagnostic test used in making that diagnosis, and a substantial number of those who have had the test do not meet the criteria for that diagnosis. In addition, studies indicate that there are many patients who have COPD in whom the diagnosis has not been made by a physician. Zaas et al carried out a study of the prevalence of airflow obstruction among pa-

tients admitted to an acute medical ward at a large urban hospital, and determined how many of those patients carried a diagnosis compatible with this finding.[21] Of 126 patients admitted to the ward with a variety of diagnoses and who completed a questionnaire and underwent spirometry, 26% had an FEV_1/FVC ratio of less than 0.70 (the diagnostic threshold for COPD used by the Global Initiative for Chronic Obstructive Lung Disease[16]), but less than one third of those whose results showed mild, moderate, or even severe obstruction had a diagnosis compatible with obstructive lung disease on hospital discharge.

According to the findings of the National Health Interview Survey of American households in 2000, about 10 million people in this country have been diagnosed by their physicians as having COPD.[22] This represents less than half of all the individuals who actually have COPD, which has been estimated by the Third National Health and Nutrition Examination Survey (NHANES III) to be 23.6 million people, or 13.9% of adults age 18 years and older.[23] Thus, clinicians are often wrong when they make the diagnosis of COPD; spirometry is not used in staging the disease and thus determining appropriate evidence-based treatment when the diagnosis is made; and the majority of actual cases of COPD in the United States have not been diagnosed.

Noninvasive Ventilation for Acute Respiratory Failure in Chronic Obstructive Pulmonary Disease

The acute application of noninvasive ventilation (NIV) has now been studied in many randomized clinical trials, and in no setting is the evidence supporting its use so clearly and consistently positive as in acute respiratory failure complicating COPD.[24-27] The number-needed-to-treat is 4 to prevent one intubation, and 10 to save one life, in comparison with best current management without NIV. However, several studies show that adoption of this life-saving therapy for this common clinical problem has been slow.[10] The evidence comes from surveys in which clinicians describe how care is delivered in a variety of clinical settings, and also from observational studies to document actual practice.

Only 48% of British hospitals surveyed in 1997 reported that they had NIV available to treat acute respiratory failure in COPD.[28] Reasons cited for the lack of availability were the absence of equipment and a lack of training on the part of both physicians and staff. In a 2001 survey of emergency departments in Belgium, NIV was offered in the treatment of patients with COPD in only 49%, again with lack of available equipment and untrained staff as prominent explanations.[29] A 2003 survey of attending and resident physicians at 15 teaching hospitals in Ontario found that only about two thirds of respondents had used NIV in treating acute respiratory failure, and 3 of the 15 hospitals had no protocols, guidelines, or other formal policies in place dealing with NIV.[30]

The acute application of NIV in 81 acute-care hospitals in Massachusetts and Rhode Island during 2002-2003 was surveyed by Maheshwari et al, who found that, while it was available in virtually all of them, NIV was used in only 20% of mechanical ventilation starts.[31] There was a great deal of variability among the different institutions, with larger teaching hospitals using NIV more often than others. Drummond and colleagues surveyed all 33 Canadian acute-care hospitals of more than 200 beds that had pulmonary training programs.[32] They found that, while it was available in all of them, NIV was used on fewer than 5 patients per month in more than half of the hospitals; again, there was marked variability in reported NIV use in the various centers.

Marked inter-institutional and regional variability in NIV use was also found in a cross-sectional Web-based survey of European and North American intensivist physicians by Devlin et al.[33] In this study, COPD exacerbation was the diagnosis in which NIV was most likely to be used, but only a minority of physicians reported using NIV even 25% of the time in acute respiratory failure.

Observational studies of how clinicians actually use NIV have also shown considerable variation across regions and among institutions, but they suggest that its use in COPD exacerbations is becoming more widespread, if not standard of care. Girou et al[34] documented increasing use of NIV for COPD exacerbations and congestive heart failure in the medical ICU of one French teaching hospital between 1994 and 2001. In their 1998 study of mechanical ventilation practice during a one-month observation period in 361 ICUs in 20 countries, Esteban and associates[35] found that NIV was the initial approach in less than 5% of patients. In one third of the patients who received NIV, the reason was a COPD exacerbation. These same investigators performed a follow-up study in many of the same ICUs during 2004, and found that NIV use had increased from 4.9% to 11% of all ventilated patients, including 48 of 109 patients with COPD exacerbations.[36] More recently, Ozsancak et al[37] reported in abstract form on a follow-up study of NIV use in 8 "low-utilization" hospitals, as identified by the previous survey by the same group.[31] In a one-month cohort study in these 8 institutions the investigators found that COPD exacerbations accounted for 25% of all acute-care NIV applications, and that NIV was the initial ventilation support approach in 81% of COPD exacerbations.[37]

Thus, there is some evidence of wider application of NIV in the management of COPD exacerbations over time. However, an important gap clearly remains. In a quality-improvement study carried out in a Vancouver, British Columbia, teaching hospital, Sweet et al reviewed all ICU admissions for exacerbations of COPD or cardiogenic pulmonary edema to determine what proportion of such patients who would have been good candidates for NIV ac-

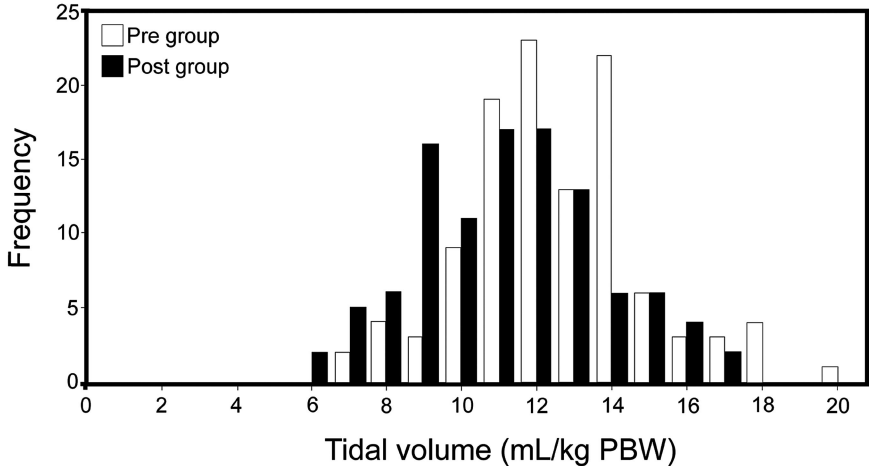

Fig. 5. Delivered tidal volumes, expressed in mL/kg predicted body weight (PBW), in 300 patients with acute lung injury/acute respiratory distress syndrome (ARDS) managed either before release of the ARDS Network trial[14] (white bars) or during 12 months soon after publication of that study (black bars). Although there was a shift toward lower tidal volumes, the majority of settings continued to exceed those used in the trial. (Adapted from Reference 48.)

cording to best evidence actually received this therapy.[38] They selected only patients with primary respiratory failure who were alert and cooperative and had no contraindications to NIV. Of the 44 patients with COPD exacerbations who were admitted to the ICU during the study period, were good NIV candidates, and received ventilatory assistance, only 16 (36%) received a trial of NIV. The authors concluded that, although there could have been inapparent or unrecorded reasons why NIV should not have been used in some of the directly intubated patients, the fact that nearly two thirds of this cohort who appeared to be appropriate for this therapy did not receive it represents a missed opportunity for potentially life-saving treatment, and a potential focus for increased efforts at education and care standardization.

Lung-Protective Ventilation for Acute Lung Injury

Along with NIV for COPD, LPV for ALI and ARDS represents the most striking advance in mechanical ventilation in the last 40 years.[39-41] From the landmark ARDS Network trial,[14] the number-needed-to-treat in ALI-ARDS to save a life is 11. That is, for every 11 patients ventilated with a tidal volume (V_T) of 6 mL/kg predicted body weight (PBW) and end-inspiratory plateau pressure < 30 cm H_2O, as compared to V_T 12 mL/kg PBW and a higher plateau pressure, one patient will survive who otherwise would die. Low-V_T, low-plateau-pressure ventilation is now the standard of care for ALI-ARDS, as recommended in current practice guidelines[42] and an increasing number of reviews, editorials, and book chapters.

Unlike many so-called advances in mechanical ventilation, LPV does not involve the use of special equipment or specialized, advanced training. Given its relative simplicity and profound impact on patient-relevant outcomes, one would assume that LPV would have been adopted by clinicians and institutions everywhere. However, there is considerable evidence to the contrary.[43-46]

Weinert and colleagues[47] examined the V_T used in ventilating 398 patients with ALI or ARDS at 3 teaching hospitals from 1994 through 2001, to see whether there had been a decrease following publication of the ARDS Network study. They found that V_T averaged 11.2 mL/kg PBW during the first 5 years and 10.1 mL/kg PBW during the final 2 years of the study. Throughout the period reviewed, only 0.9% of the patients received V_T of 6.2 mL/kg PBW or less.

In a similar study, Young et al[48] retrospectively reviewed the V_T used in managing 300 patients meeting the American-European Consensus Conference definition of ALI or ARDS[49] at 3 New England tertiary-care hospitals before and after publication of the ARDS Network study.[14] They compared V_T in patients managed during the year prior to that study's release to those managed during the year following its publication. Figures 5 and 6 show the results.[48] Both mean and median V_T were larger in the earlier group (12.3 ± 2.7 and 11.7 mL/kg PBW, respectively) than in the later cohort (10.6 ± 2.4 and 10.7 mL/kg PBW, respectively, $P < .001$). End-inspiratory plateau pressures in the pre-publication and post-publication periods were not significantly different. As in the Weinert study, although there had been a general decrease, the majority of patients continued to receive V_T well in excess of that prescribed by the ARDS Network protocol.

Investigators at other centers—even those who participated in the original ARDS Network trial[50-52]—have re-

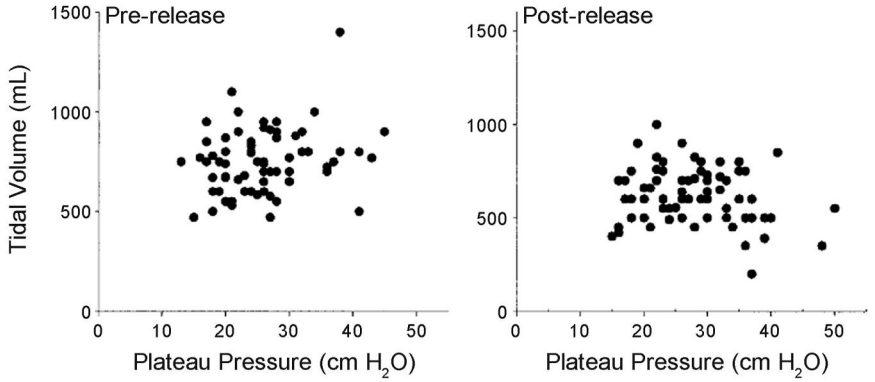

Fig. 6. Tidal volumes plotted as a function of plateau pressure for individual patients with acute lung injury/acute respiratory distress syndrome (ARDS) before and after publication of the ARDS Network low-tidal-volume study.[14] While there was a trend toward both lower volumes and lower pressures, many patients continued to be managed well outside the target ranges. (From Reference 48, with permission.)

ported similar findings. At the University of Amsterdam, 3 years after publication of the ARDS Network trial, V_T for all ventilated patients was 10 ± 2 mL/kg PBW, with no differences between patients with healthy lungs and those with ALI or ARDS.[43] The same group found that 24 patients meeting diagnostic criteria for ALI-ARDS similar to those of the American-European Consensus Conference[49] who were ventilated in 2003 received a mean V_T of 9.9 mL/kg PBW.[53] These investigators recorded V_T 3 times daily in these patients, and found that 85% and 39% of the volumes charted exceeded 8 and 10 mL/kg PBW, respectively.[53] In 3 teaching hospitals in Baltimore, Umoh et al[52] found that 81% of patients with ALI-ARDS received V_T of 8.5 mL/kg PBW or less, and that only 46% were ventilated at the authors' target V_T of 6.5 mL/kg PBW or less.

For a 2-year period beginning several months after publication of the ARDS Network study, Kalhan and colleagues at the University of Pennsylvania determined the proportion of patients with ALI-ARDS who were ventilated with V_T of 7.5 mL/kg PBW or less 2, 4, and 7 days after meeting diagnostic criteria, and in a sensitivity analysis also determined these proportions for V_T of 6.5 and 8.5 mL/kg PBW.[51] As shown in Figure 7,[51] although there was a tendency for V_T to be reduced with increasing duration of mechanical ventilation, the majority of patients did not receive LPV according to the ARDS Network protocol. This was the case despite the fact that an alert automatically appeared on the monitor during electronic order entry for all ventilator orders, reminding the ordering physician to use the institution's ARDS-Network-based LPV protocol.

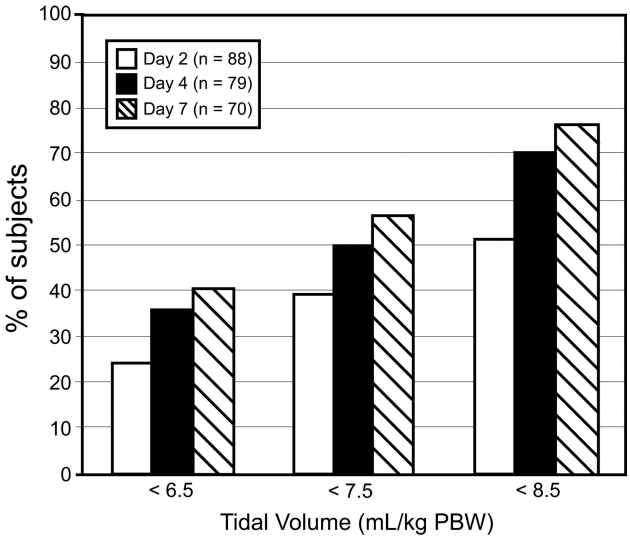

Fig. 7. Percentage of patients who received tidal volumes equal to or less than the values specified on days 2, 4, and 7 of mechanical ventilation after meeting diagnostic criteria for acute lung injury/acute respiratory distress syndrome (ARDS). Only a minority of patients received the tidal volumes used in the ARDS Network study,[14] even after a week. (Adapted from Reference 51.)

Barriers to Putting Best Evidence Into Practice

The preceding examples are only a sampling of available documentation that the availability of high-quality evidence and authoritative clinical practice guidelines does not lead automatically to practice change, and thus to increased benefit to patients. Before measures can be enacted to achieve practice change, it is necessary to understand why this is the case. A number of studies have been done in attempts to identify the barriers involved.

Why Clinicians Don't Use Practice Guidelines

In a widely-cited study, Cabana and associates performed a comprehensive review of the existing literature on barriers to the adoption of practice guidelines.[54] They identified 120 surveys investigating 293 potential barriers to physician guideline adherence, published in 76 different

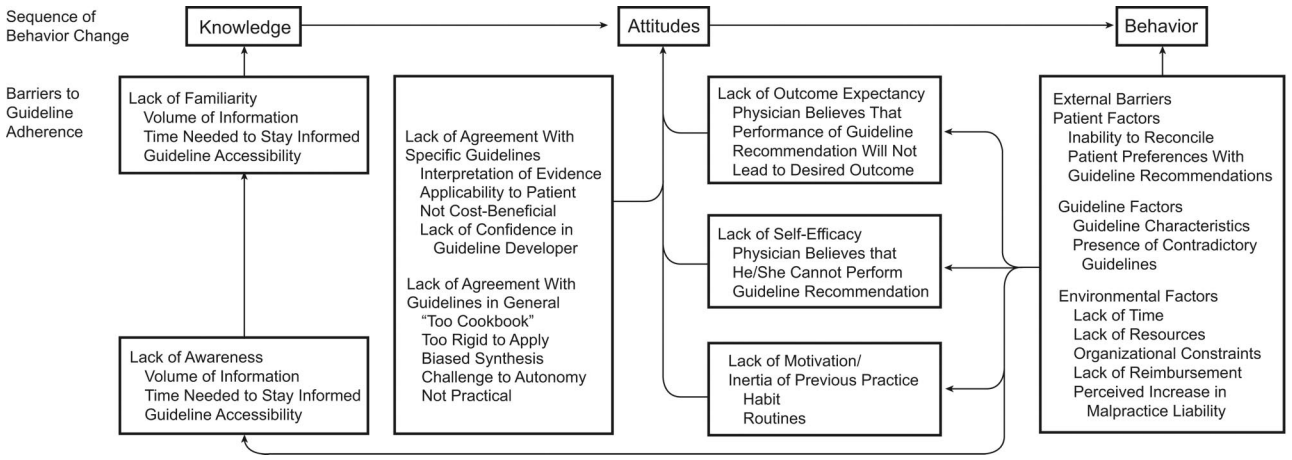

Fig. 8. Barriers to physician adherence to practice guidelines in relation to behavior change, based on a comprehensive review of the existing literature, by Cabana et al.[54] (From Reference 54, with permission.)

articles, and described 7 separate categories of barriers (Fig. 8).[54] The studies dealt specifically with physician behavior, although the conclusions may apply more broadly and thus be applicable to other clinicians involved in respiratory care.

Cabana et al identified *lack of awareness* as an important barrier, given the rapid proliferation of guidelines, even in specialized subject areas, such that it may be difficult for clinicians to know about all of them. In many of the studies reviewed, *lack of familiarity with guideline content* was more common than lack of awareness. *Lack of agreement* can be an important barrier, such that clinicians may not accept the guidelines' recommendations even when they are familiar with them; this has clearly been a factor for some in adopting LPV for ALI-ARDS. Figure 8 illustrates some of the ways in which physicians may indicate lack of agreement with guideline recommendations.

Lack of outcome expectancy may prevent guideline implementation when the clinician has little confidence that the intervention will be effective. This is believed to be an important barrier to the widespread adoption of smoking-cessation counseling in physician practices: clinicians are loathe to expend effort when they have little expectation that it will have a measurable effect. Self-efficacy refers to the belief that one can actually carry out a given behavior. *Lack of self-efficacy* has been invoked as an important barrier to guideline implementation, as for example when the recommended measures are perceived to be too complicated or difficult to carry out.

Lack of motivation to change and *inertia of previous practice* represent less-studied but doubtless important barriers to guideline adherence. Just as many smokers must progress through a sequence of steps (contemplation, preparation, action, and so forth) in order to quit successfully, changing long-established clinician behavior may require multiple stages and interventions.

Cabana et al also identified several *external barriers* to the implementation of practice guidelines.[54] These include barriers related to the patient, as when guideline recommendations conflict with patient preference due to cultural or other factors. Aspects of the guideline itself may pose barriers to implementation, as when it is unnecessarily complex or its recommendations are difficult or time-consuming to carry out. Finally, environmental factors such as limited time and resources, lack of incentives, or organizational obstacles can serve as barriers for clinicians, even when they are motivated to adopt practices recommended by guidelines.

Each of these types of barriers to guideline implementation has familiar examples in respiratory care. Kahn[46] classified the barriers described by Cabana et al[54] into those having to do with clinician knowledge, attitudes, and behavior, and provided concrete examples of each type, as encountered in the ICU (Table 2).[46]

Barriers to the Use of Lung-Protective Ventilation

Most of the barriers discussed above apply to some extent to the implementation of lung-protective, low-V_T ventilation for patients with ALI or ARDS. Others may be unique to this issue.

Rubenfeld and colleagues surveyed experienced ICU nurses and respiratory therapists at all 10 of the original ARDS Network study sites to determine what barriers they felt existed in their institutions with respect to the implementation of LPV.[58] Nurses and respiratory therapists were about evenly represented, and the respondents were experienced with LPV, having used it in a median of 20 patients each. There were no significant differences between the responses of the 2 groups. The investigators separated the barriers into those to initiating LPV and those to continuing it once begun. In the former category, the barriers

Table 2. Barriers to the Adoption of Clinical Evidence Into Practice in Critical Care

Category	Specific Barriers	Examples in Critical Care
Knowledge	Clinician is not aware of evidence	Some clinicians were not aware that semirecumbency can prevent ventilator-associated pneumonia[55]
	Clinician is not familiar with certain guidelines	Clinicians may feel they adhere to sedation guidelines while their actual practice can differ[56]
Attitudes	Clinician does not agree with evidence	Many clinicians do not agree that some practices for prevention of ventilator-associated pneumonia are effective[57]
	Clinician does not believe that practice is feasible	Respiratory therapists perceive that physicians will not want to give up control of ventilator in order to implement lung-protective ventilation[58]
	Clinician is not motivated to change practice	The culture of the intensive care unit is not conducive to change[59]
Behavior	External barriers to adoption of practice	Emergency department physicians are too busy to place a central line for early goal-directed therapy for sepsis[60]
	Internal barriers to adoption of practice	Algorithm for conservative fluid strategy may be too complex to adopt routinely into practice[61]
	Environmental barriers to adoption of practice	Physicians and nurses are not communicating about need for semirecumbency to prevent ventilator-associated pneumonia[55]

(From Reference 46, as adapted from Reference 54.)

considered most important by the respondents were physician unwillingness to relinquish control over the ventilator, followed by failure of the physician to recognize that the patient had ALI-ARDS. Among barriers to continuing LPV, most prominent were concerns over patient discomfort and tachypnea; hypercapnia and acidosis; and declining oxygenation at the lower V_T and pressure. Clinicians also reported difficulty in calculating V_T on the basis of PBW and in using an LPV protocol correctly.

The authors emphasized the need for education in overcoming several of the barriers identified in their study. For example, the perceived increased requirement for sedative drugs with LPV has not been borne out by studies conducted both during the ARDS Network trial[62] and subsequently elsewhere.[63]

One possible reason why so few patients meeting accepted diagnostic criteria for ALI-ARDS receive LPV is that their physicians fail to make the diagnosis. In the study by Kalhan et al mentioned previously,[51] patients with ALI-ARDS were identified by trained research nurses looking specifically for this diagnosis among mechanically ventilated patients. This case-finding activity did not directly involve the clinicians managing the patients, and the proportion of patients in whom the diagnosis was made correctly by the latter is unknown. In a study by Howard and colleagues of patients admitted to a medical ICU, only 31 of 65 cases of ARDS prospectively identified by the investigators using accepted criteria had this diagnosis mentioned in the progress notes by their managing physicians, and only 4 of these were subsequently assigned a diagnosis code for ARDS.[64] A smaller study by Cedeño et al found that only 4 of 21 patients considered by the authors to have ARDS had this diagnosis recorded in their charts.[65]

In part, inconsistency in diagnosing ALI-ARDS reflects the imprecision of clinical judgment in determining whether the criteria are met. Rubenfeld et al showed 28 randomly selected portable chest radiographs from critically ill patients who met the American-European Consensus Conference's oxygenation criterion for ALI to 21 recognized experts in ALI-ARDS.[66] Essentially complete agreement (20 or 21 readers in agreement) on the presence or absence of ALI-ARDS based on the chest radiograph was observed with 13 of the 28 films. However, 9 radiographs (32%) had at least 5 dissenting readers, and the proportion of films read as consistent with ALI-ARDS by the different participants varied from 36% to 71%.

In addition, clinical criteria for making the diagnosis vary and do not correlate perfectly with pathologic findings considered characteristic for ARDS. Ferguson and colleagues applied 3 different sets of clinical diagnostic criteria for ARDS in a series of 138 mechanically ventilated patients who died and were autopsied.[67] Forty-two of these patients (30.4%) had diffuse alveolar damage, the pathologic correlate of ARDS. However, only 20 of those patients 42 (47.6%) had ARDS mentioned in their charts. That is, in a cohort of patients with presumably severe ARDS, who died with it, the diagnosis was made less than half the time. In this study the American-European definition[49] had a sensitivity of 0.83 and a specificity of 0.51.

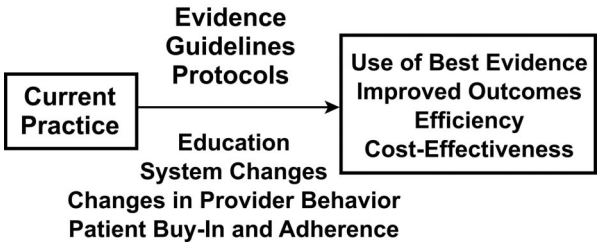

Fig. 9. Improving patient care through the different elements of knowledge translation. Best evidence is but the first of several components that must work effectively together for maximum improvements in patient care.

The Lung Injury Score[68] and a newer, Delphi diagnostic scheme[69] had somewhat higher specificity but lower sensitivity.

Given the poor performance of physicians in diagnosing ALI-ARDS when accepted criteria are met, and the inherent difficulties of deciding whether the radiographic criteria are met, clinicians in some institutions are adopting a policy by which all patients with acute respiratory failure are managed with LPV. Although it is controversial and not all experts in the field agree, a good argument can be made in favor of this strategy.[70]

Knowledge Translation: Overcoming the Barriers

Knowledge translation is the process of putting the results of research and other evidence into use in everyday practice. It has also been called knowledge transfer, evidence diffusion, and diffusion of innovation, although not every author agrees that these are interchangeable terms. In health care, to achieve the ultimate goals of more accurate diagnosis, more effective therapy, and better outcomes for both the individual patient and the health-care system, KT is necessarily a complicated, multi-tiered process involving every component of an increasingly complex environment. Figure 9 shows some of the components, illustrating how much more complicated the situation is than that depicted in Figure 1. The figure does not include the economic, political, and practical, ground-level logistical aspects of the system that have to function well enough together for the process to work.

That interest and activity in this field have increased greatly in the recent past is illustrated by the results of a PubMed search performed on July 18, 2009. A search for the terms "knowledge translation" or "knowledge transfer" yielded 588 citations published in the last 10 years, 515 of them in the last 5 years, 296 in the last 2 years, and 135 in the year preceding the query. However, little of that published activity has been in the field of respiratory care. Narrowing the above search to include "critical care" produced 31 citations to articles published in the last 10 years; when "respiratory care" was substituted only 9 articles were identified. However, while not necessarily indexed under KT, a number of studies pertinent to this subject have recently appeared to demonstrate that evidence can be used more effectively in caring for patients with respiratory disorders. The following summaries, while not comprehensive, provide an indication of the progress that can be achieved.

Improving Asthma Management

As the prevalence and impact of asthma increase around the world, evidence-based guidelines have been developed and updated[71,72] and international collaborative programs have focused on their more effective implementation.[73-75] Comprehensive, national efforts focusing on KT as it applies to asthma[76] have produced measurable improvements in the care of patients with this disease.[77] An example has recently been reported from Finland, and it illustrates not only the improvements in patient-relevant outcomes and cost savings that can be achieved, but also the complexity and effort involved in such a comprehensive, system-wide initiative, requiring participation at every level, from government to regional health-care institution to individual provider to patient.[78]

In 1994 a nationwide program was initiated in Finland with the primary goal of lessening the burden of asthma to individuals and society.[78] Every element of that country's health-care system was involved. The federal government acknowledged the problems posed by the increasing incidence and severity of asthma and committed resources in support of the program. A separate nongovernmental organization, the Finnish Lung Health Association, was established to coordinate it, and a coordinating committee representing all the major stakeholders (state officials, key experts, nurses, pharmacists, and patient organizations) established a series of specific goals for the 10-year program:

- Earlier diagnosis and treatment
- Guided self-management as the primary form of treatment
- Reduction in irritant exposure, especially to smoking
- Integration of individualized patient education and rehabilitation into normal treatment
- Increase in asthma knowledge on the part of specialists, general practitioners, nurses, and pharmacists

A clinical practice guideline for asthma was already in place, and region-specific versions were developed. Efforts were made to obtain buy-in from all components of the health-care system. A nationwide network of regional asthma coordinating centers was established, with a physician to serve as a resource to the region's other specialist

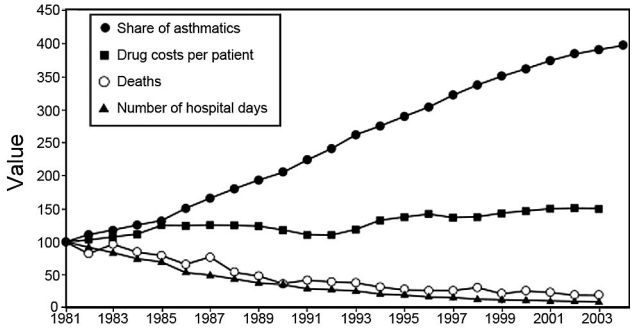

Fig. 10. Changes in numbers of asthmatics enrolled in a governmental reimbursement program, drug costs, hospital days, and deaths from asthma in Finland between 1981 and 2003. The Finnish Asthma Programme covers the last 10 years of this period. The numbers are relative to their values as of 1981. (Adapted from Reference 78.)

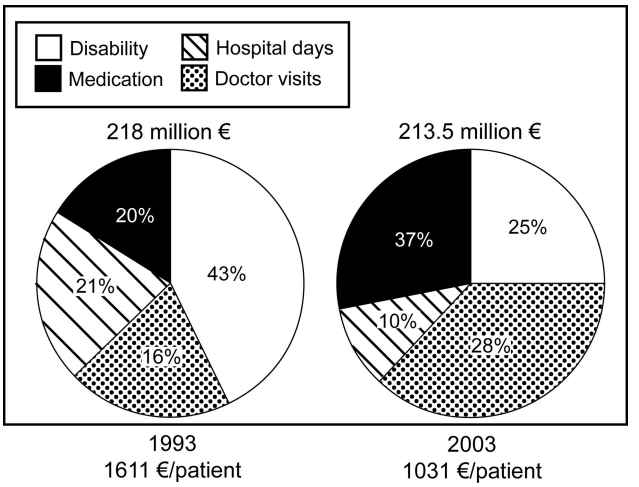

Fig. 11. Direct annual costs of disability, medication, hospital days, and doctor visits for asthma in Finland in 1993 and 2003 after implementation of the Finnish Asthma Programme. Finland's gross national product per capita increased from €19,809 to €27,585 during this period, but the costs are shown relative to 2003. (Adapted from Reference 78.)

physicians and to facilitate communication between those specialists and primary care providers, and with an asthma nurse, whose responsibilities included patient education and serving as contact person for patients in the system. In addition, essentially all Finnish pharmacies were recruited into the program, for patient instruction and monitoring of asthma drug use. The program included extensive regional education offerings for providers, both general practitioners and specialists. Built in was a comprehensive system for monitoring and tracking the program's results.

The program was remarkably successful in achieving its goals.[78] A large majority of members of all segments of the health-care system participated. As of 2000, essentially all health centers throughout the country had peak flow meters and spirometry available, used guided self-management, had a designated local asthma-responsible provider, and were using inhaled corticosteroids as first-line therapy. Regional asthma programs for patients, diagnosis of adult patients with asthma within the system, and annual follow-up visits for asthmatics had been established in at least three fourths of centers. Special asthma education sessions (mean 1.6 sessions/center/year) were taking place at most centers. Regionally tailored practice guidelines were in place in 71% of hospital districts, and care had largely shifted from specialists to general practitioners throughout the country. By 2003 virtually all new asthmatics received instruction on inhaler technique from pharmacists when the prescription was filled, with direct observation of technique in more than half.

During the 10-year program the incidence of asthma continued to increase. As shown in Figure 10,[78] there was a steady increase in the number of patients enrolled in a special drug-reimbursement program for asthma. Medication use increased substantially, with 85% of asthmatics using inhaled corticosteroids in 2003, as compared to 33% in 1987. However, emergency department visits for asthma fell, by 24% for adults and by 61% for children in one district; hospitalizations for asthma declined by 54% nationwide (69% in relation to the numbers of asthmatics), to only 10% of the 1981 rate, and deaths from asthma fell from 123 in 1993 (0.91 per 1,000 population) to 85 in 2003 (0.41/1,000).

Total costs attributable to asthma in Finland fell during the 10-year program (Fig. 11),[78] despite the substantial increase in the overall number of asthmatics and a big increase in drug costs. Total direct costs for asthma and work disability in 1993 were €218 million, as compared to €213.5 million in 2003, corrected for inflation. The cost per patient was 36% less, at €1,031/patient/year.

Thus, intensive, multifaceted programs at the system level (in this case at the national level) cannot only improve asthma care for the individual patient (fewer hospitalizations and disability designations), but also at the societal level (cost of care per asthma patient and overall cost to the system).

Implementing Lung-Protective Ventilation

Although the challenges it presents are different from those encountered in managing asthma, progress has been made in understanding factors that impact the implementation of LPV in institutions, and also in strategies for increasing its use by clinicians. For example, mechanically ventilated patients who are managed at higher-volume hospitals have better outcomes.[79] Clinicians practicing in closed ICUs are more likely to use LPV in patients with ALI or ARDS,[80] and such patients have better outcomes if managed in closed ICUs, even after taking into account various potential confounding factors.[81]

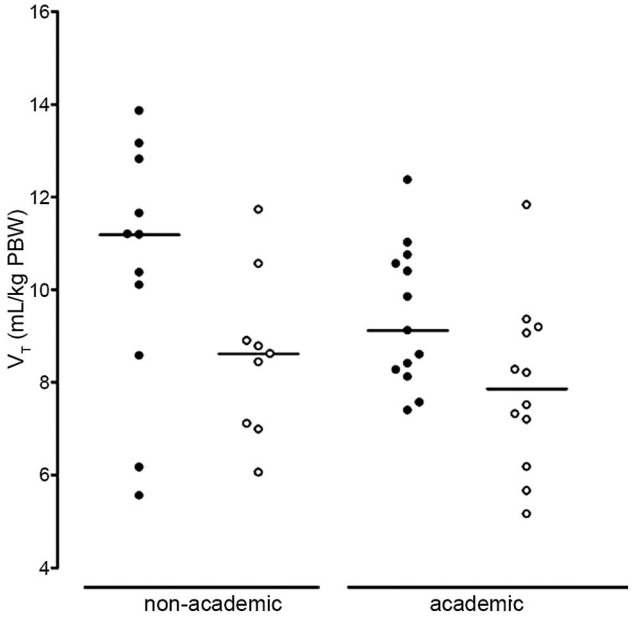

Fig. 12. Tidal volumes (V_T) used in ventilating patients with acute lung injury/acute respiratory distress syndrome at an academic medical center and 2 non-academic medical centers in The Netherlands, before (solid circles) and after (open circles) providing feedback and education to the physicians and nurses in the intensive care units. V_T declined significantly only in the academic medical center, and nearly all patients were ventilated with values exceeding 6 mL/kg predicted body weight (PBW). (Adapted from Reference 53.)

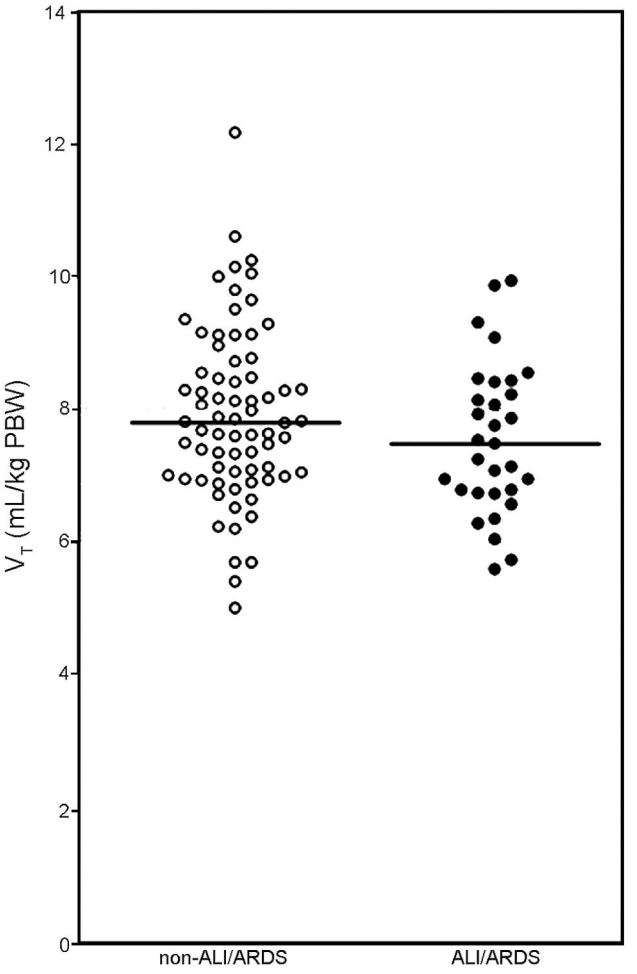

Fig. 13. Tidal volumes, expressed in mL/kg predicted body weight (PBW), in patients with and without acute lung injury/acute respiratory distress syndrome (ALI/ARDS) at an academic medical center 12 months after feedback and education on lung-protective ventilation. (Adapted from Reference 53.)

Wolthuis and colleagues studied the effect of feedback and education on the V_T used in ventilating patients with ALI or ARDS in the closed ICUs of one academic and 2 non-academic medical centers in Amsterdam.[53] The intervention consisted of presenting to the physicians and nurses in those ICUs the results of a preliminary assessment of the V_T used, reviewing the rationale for LPV and the clinical evidence supporting it, and explaining the calculation and use of PBW rather than measured body weight in setting the V_T. A protocol for LPV was also introduced at one of the non-academic hospitals as part of the study intervention. The results are shown in Figure 12,[53] demonstrating a significant reduction in V_T in ALI-ARDS patients at the academic medical center, but not at the 2 non-academic institutions. To assess the long-term effects, the authors repeated the observations 12 months after the intervention in the academic medical center (Fig. 13).[53] V_T did not change between 6 and 12 months following feedback and education, and remained significantly lower than before the intervention in both ALI-ARDS and non ALI-ARDS patients. However, the great majority of patients continued to be ventilated with V_T greater than 6 mL/kg PBW.

A more recent study from the same group sought to determine the effect of a computerized decision-support system on adherence to recommendations for setting V_T.[82] The system automatically calculated a V_T of 6 mL/kg PBW and recommended it to the ordering physician in a pop-up window on the monitor. For 15 weeks before and 15 weeks after introduction of the decision-support system the investigators determined actual delivered V_T for all ventilated patients in their 30-bed closed ICU. Before and after the intervention there were no differences in the V_T used in 333 patients ventilated between 1 h and 24 h, but for 363 patients ventilated for more than 24 h, the V_T was lower after introduction of the computerized decision-support system. However, the impact was small, even though, given the large number of individual measurements, the differences were statistically significant. "Excessive V_T," defined by the authors as the mean volume exceeding 6 mL/kg PBW, was 1.86 mL before and 1.52 mL after the intervention. V_T was above 8 mL/kg PBW 36.8% of the

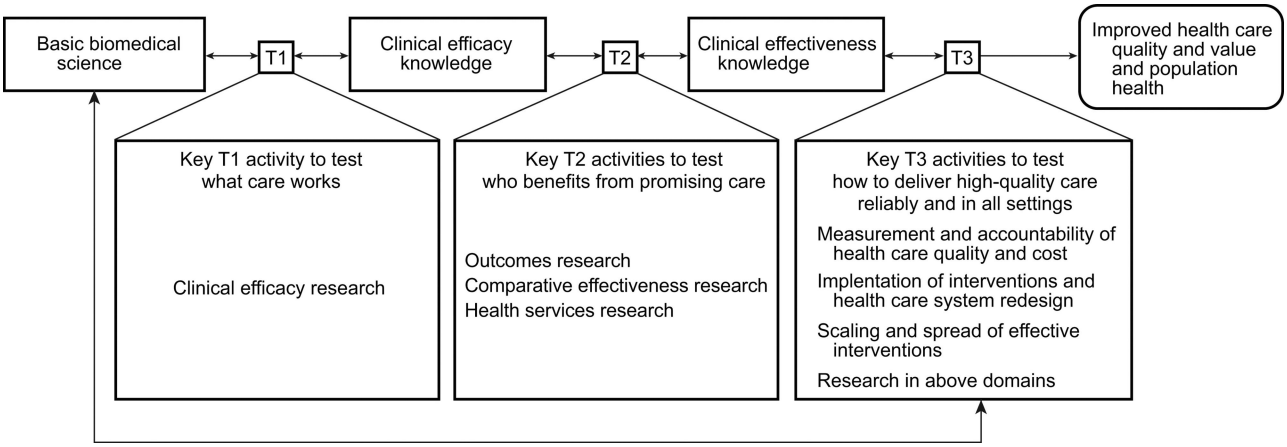

Fig. 14. The "3Ts" road map for transforming health care in the United States. T1, T2, and T3 represent the major translational steps in the model proposed by Dougherty and Conway for facilitating knowledge translation in all aspects of health care and on a national scale. The activities in each translational step test the discoveries of the previous step. Double-headed arrows represent the essential need for feedback loops between and across the parts of the model. (From Reference 85, with permission.)

time before, and 28.6% of the time after the introduction of the decision-support system; the corresponding values for V_T exceeding 6 mL/kg PBW were 64.8% and 58.6%, respectively.[53]

A recent study included LPV as one component of a multi-part ventilator bundle, and found that, while adherence to other components of the bundle increased, no effect on V_T was seen.[83] Concern about increased costs associated with LPV should not be an impediment to the wider implementation of this practice, as another recent study showed that implementing LPV was cost-effective even when doing so involved a comprehensive educational intervention.[84]

Realizing the Benefits of Available Evidence: What Needs to Be Done

The examples described above illustrate the magnitude and complexity of KT in health care. They also show the importance of viewing the task of implementing best practice as one for the whole system. Under the Finnish asthma program, medication costs went up, and doctor visits for asthma increased, but the system as a whole saved money because of reductions in emergency visits, hospitalization, and chronic disability payments.[78] Finland has one fiftieth the population of the United States, and a very different health-care system. The challenge for any KT initiative is much greater the more complex the health-care system and the more independent its various segments are. However, a great deal of work is currently being done to tackle this problem in the United States.

One approach to clarifying the process and better understanding what has to be done to implement KT nationally has recently been provided by Dougherty and Conway, by means of their "3Ts" (translational steps) road map for transforming health care (Fig. 14).[85] The 3Ts represent 3 sequential steps in translating basic research into improved patient care. The first "T" is clinical efficacy research, to determine what treatments are effective and how to apply them under controlled conditions. The second comprises activities to move from efficacy to clinical effectiveness, including outcomes research, comparative effectiveness research, and health services research. Included in this second "T" is the development of evidence-based clinical practice guidelines for application of the knowledge gained in the first step to the care of individual patients. The third "T" deals with the "how" of health-care delivery, the translation of knowledge about clinical effectiveness into improved health care to individuals, regardless of context, as well as to the nation as a whole. The activities involved in T3 include measurement of health-care quality and cost and the implementation of accountability for these things; putting interventions into effect, including health-care-system redesign as required; scaling and spread of effective interventions; and monitoring and research into these activities.

Dougherty and Conway emphasize that taking advantage of this conceptual road map would require leadership, teamwork, and the right tools and resources.[85] The leadership would have to involve the federal government and a number of private-sector entities, but also leadership at the local level. Collaboration and cooperation among the many components of the system would be required. Tools necessary to make it work would include effective application of health-information technology to the tasks involved, including comparative effectiveness studies and quality-improvement activities. And effective implementation of widespread KT via this road map would require

a great deal of resources, of different types, but especially funding.

Another model addressing KT in health care that attempts to provide the means for implementation as well as a conceptual framework for understanding the task was recently published by Pronovost et al.[86] This model is an extension of these authors' integrated approach to reducing bloodstream infections associated with central lines, which has been shown to be effective in that context.[87] Pronovost et al emphasize the importance of a systems approach that deals with how work is organized, rather than the care of individual patients. Other components of their model are the engagement of local interdisciplinary teams to assume ownership of the KT project, providing centralized support for the technical work, encouraging local adoption of the intervention, and creating a collaborative culture within both the local unit and the larger system.[86] The authors' model has 4 parts:

- Summarizing the evidence, including identifying the most potentially effective interventions and expressing them as behaviors that can be adopted
- Identifying local barriers to implementation of the intervention, including all stakeholders, and describing every step in the context of the local environment
- Measuring performance, using appropriate process or outcome measures after adequately assessing baseline performance
- Ensuring that all patients receive the intervention, using a formalized process for engagement, education, execution, and evaluation that involves all relevant parties

These models are intended to be applicable to health care as a whole, and are not aimed at any particular specialty. However, considering what is known about the gaps in applying the available evidence to patient care in respiratory care, they should be as applicable in this field as elsewhere. Much of the change that must take place to implement KT will have to be at the organizational level, but there is much that individual clinicians can do to further the process. They can become more familiar with current evidence relevant to their practice, including guidelines and protocols in effect in their institutions; they can assure their own adherence to them in managing their patients; and they can participate in quality-improvement and other activities involved in KT at the local level.

Summary

Research to determine best evidence for managing patients, and the publication and dissemination of that evidence, are complex and labor-intensive activities. As has been illustrated here, the real-world translation of study findings and evidence-based practice guidelines to the care of patients is similarly complex and far from automatic once these are made available to clinicians. Yet such translation is a necessity if the potential gains offered by current evidence are to be realized. Differences between the efficacy of a treatment, as demonstrated in the research context, and its clinical effectiveness in everyday practice, have many origins. Some components of a complex management regimen are easier for both clinicians and patients to carry out than others,[88] yet benefits requiring the coordinated application of all components are unlikely to be realized if the interventions are only partially applied. Successful KT in respiratory care, as in other areas of health care, will require the coordinated and collaborative efforts of all participants in the system, and this will likely involve major organizational and behavioral changes at every level.

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