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The Canadian Critical Care Nutrition Guidelines in 2013: An Update on Current Recommendations and Implementation Strategies

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Abstract

Clinical practice guidelines (CPGs) are systematically developed statements to assist practitioners and patient decisions about appropriate healthcare for specific clinical circumstances, and are designed to minimize practice variation, improve costs, and improve clinical outcomes. The Canadian Critical Care Practice Guidelines (CCPGs) were first published in 2003 and most recently updated in 2013. A total of 68 new randomized controlled trials were identified since the last version in 2009, 50 of them published between 2009 and 2013. The remaining articles were trials published before 2009 but were not identified in previous iterations of the CCPGs. For clinical practice guidelines to be useful to practitioners, they need to be up-to-date and be reflective of the current body of evidence. Herein we describe the process by which the CCPGs were updated. This process resulted in 10 new sections or clinical topics. Of the old clinical topics, 3 recommendations were upgraded, 4 were downgraded, and 27 remained the same. To influence decision making at the bedside, these updated guidelines need to be accompanied by active guideline implementation strategies. Optimal implementation strategies should be guided by local contextual factors including barriers and facilitators to best practice recommendations. Moreover, evaluating and monitoring performance, such as participating in the International Nutrition Survey of practice, should be part of any intensive care unit's performance improvement strategy. The active implementation of the updated CCPGs may lead to better nutrition care and improved patient outcomes in the critical care setting. (*Nutr Clin Pract*. 2014;29:29-43)

Keywords

critical care; guidelines; nutrition therapy; critical illness; evidence-based practice; nutritional support; enteral nutrition; parenteral nutrition

When applied appropriately, nutrition therapy provided to critically ill patients can result in reduced mortality,[1,2] fewer infections[3,4,5] and better health-related quality of life.[6] However, there is the potential to do harm, particularly if used inappropriately or with the wrong patient population.[7,8] Over the past 4 years, there have been at least 120 randomized controlled trials published in the area of critical care nutrition. Despite the issues around the quality of the literature published and the need for better designed trials,[9] several recent landmark studies[8,10-12] have been published with results contradictory to previous studies and prevailing wisdom. Given the large volume of the evolving nature of the evidence in nutrition, it is challenging for intensive care unit (ICU) practitioners to keep abreast of and adopt best practices. Audits of current nutrition practices in the ICU have repeatedly demonstrated suboptimal and wide variation in practices in Canada and across the world,[13,14] confirming that best practices are difficult to implement.

Clinical practice guidelines are systematically developed statement to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances,[15] are designed to minimize variation, improve costs, and improve outcomes,[16,17] and are effective in improving the process and structure of care.[18] Over the past decade, there has been a proliferation of guidelines aimed at educating the bedside ICU practitioner about nutrition therapy.[19-26] The Canadian Critical Care Practice Guidelines (CCPGs)[19] are among the most regularly updated evidence-based guidelines, with updates in 2005, 2007, 2009,[27] and their use has been quoted widely in the literature. There are many similarities in the CCPGs recommendations when compared to other North American guidelines, that is, the Society of Critical Care Medicine/the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.)[20] and the Academy of Nutrition and Dietetics Evidence Analysis Library.[24] These include the use and timing of enteral nutrition (EN), EN fish oils, body position, small bowel vs gastric feeding, and

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methods of EN infusion. Other similar recommendations include those pertaining to parenteral nutrition (PN) vs standard care, use and type of PN lipids, PN glutamine, dose of PN, and supplemental antioxidants/minerals/vitamins. On the other hand, there are stark variations in recommendations for the use of indirect calorimetry, EN target dose, EN composition (arginine, glutamine, peptides, fiber), gastric residual volumes, motility agents, use of probiotics, and intensive insulin therapy. These differences can be attributed to the inclusion of evidence from elective surgery patients, lower levels of evidence or expert opinion, lack of clarity in the link between the evidence and the recommendation, and a nonuniform way of reporting levels of evidence or grades of the recommendation.[28] Dissimilarities between the CCPGs and ESPEN guideline recommendations[22] also exist due to variability in nutrition practices and the availability of different products.

With the rapid proliferation of published articles, there is a need to incorporate the recent evidence into the existing guidelines. For updated guidelines to be implemented effectively, awareness of implementation strategies aimed around the adoption of best practices from these guidelines is also needed.

The purpose of this article is to review the recommendations from the updated 2013 CCPGs and to provide insight for ICU practitioners (doctors, registered dietitians, registered nurses, others) on how to improve adherence to the CCPGs.

Update of the CCPGs

In 2012, a multidisciplinary panel of 17 healthcare workers including doctors, registered dietitians, a registered nurse, and a pharmacist were responsible for updating the CCPGs according to the methodology described elsewhere.[19] This panel disclosed their conflicts of interests and met face-to-face or over the phone several times during the period of 12 months. From an ongoing literature search and reference lists from articles published 2009-2013, members identified articles that met the following inclusion criteria: (1) randomized controlled trial (RCT), (2) reported on clinically important outcomes (ie, mortality, infectious complications, length of stay, mechanical ventilation, etc), and (3) involved a nutrition intervention in critically ill patients. Critically ill patients were defined as patients cared for in an ICU environment who had an urgent or life-threatening complication (high baseline mortality rate ≥5%) to distinguish them from patients with elective surgery who also are cared for in some ICUs but have a low baseline mortality rate (<5%). Two panel members were assigned to each topic, and the inclusion of each article was agreed on by these members who also abstracted the relevant data from the article independently and in duplicate. Disagreements were resolved by consensus. A total of 68 new RCTs were identified since the 2009 CCPGs, 50 of them published 2009-2013. The remaining articles were trials published before 2009 but were not identified in previous iterations of the CCPGs.

Where appropriate, the meta-analyses were updated using RevMan[29] with the data from the 68 new RCTs. The number of trials and the similarities amongst study interventions and populations were considered when making decisions about statistically aggregating the data to produce an overall estimate of treatment effect. In the event that there were uncertainties about the similarity of trials, the data were included and subgroup analyses or sensitivity analyses were done to elucidate the effects of the dissimilar trials. New topics or subsections were created if the committee agreed that the intervention or population was too divergent to aggregate with the existing data. The evidence from the new trials was carefully reviewed by the committee, and values such as internal validity of the trial, effect size of the intervention and the associated confidence intervals, homogeneity/reproducibility of the results, adequacy of the control group, biological plausibility, generalizability, safety, feasibility, and cost of the intervention were developed by consensus and incorporated to develop the final recommendations.

In the 2013 CCPGs, with the addition of the new evidence, there were a total of 44 topics, of which 10 new topics/subtopics were created: intentional underfeeding: trophic vs full feeding; intentional underfeeding: hypocaloric EN; fish oil supplementation; threshold of gastric residual volumes; discarding gastric residual volumes; beta-hydroxyl methyl butyrate; early vs delayed supplemental PN; combined parenteral and enteral glutamine supplementation; carbohydrate restricted formula and insulin therapy; and Vitamin D supplementation. Of the 44 topics, 27 had new evidence. Of these, 17/27 (65%) topics already existed in the 2009 version. Of the existing topics, after reviewing the incorporation of the latest evidence and values, the CCPG panel agreed to downgrade the recommendation for enteral fish oils/borage oils/antioxidants, protein vs peptides, enteral glutamine supplementation, and parenteral glutamine supplementation, while the recommendations for the use of probiotics, type of parenteral lipids, and parenteral selenium were upgraded. The recommendations for the remaining 11 sections did not change with the incorporation of the new evidence/values. See Table 1 for the listing of key changes in recommendations in the 2013 CCPGs compared to the 2009 version. Complete details of the summaries of evidence, ratings of values, and deliberations of the committee are available online.[27] Here we provide a brief review of the major changes and the reasons for them.

Does the Use of an Enteral Formula With Fish Oils, Borage Oils, and Antioxidants Result in Improved Clinical Outcomes in the Critically Ill Adult Patient?

There were a total of 4 new RCTs of enteral fish oils, borage oils, and antioxidants published since the 2009 CCPGs,[11,30-32]

Table 1. Recommendations of 2013 Canadian Critical Care Nutrition Clinical Practice Guidelines Compared to 2009.

#	Section/New Trials	2009 Recommendation	2013 Recommendation
3.3a	Intentional underfeeding: trophic feeds vs full feeds[10,90]	NA as new section in 2013	Based on **2 level 1 studies,** in patients with ALI, an initial strategy of trophic feeds for 5 days **should not be considered**.
3.3b	Intentional underfeeding: hypocaloric EN[99]	NA as new section in 2013	There are **insufficient data** to make a recommendation on the use of hypocaloric EN in critically ill patients.
4.1b(i)	Composition of EN: fish oils, borage oils, and antioxidants[11,30-32]	Based on **1 level 1 study and 4 level 2 studies**, we **recommend** the use of an enteral formula with fish oils, borage oils and antioxidants in patients with ALI and ARDS	**Downgraded:** Based **on 2 level 1 studies and 5 level 2 studies,** the use of an enteral formula with fish oils, borage oils and antioxidants in patients with ALI and ARDS **should be considered.**
4.1b(ii)	Composition of EN: fish oil supplementation[100]	NA as new section in 2013	There are **insufficient data** to make a recommendation on the supplementation of fish oils alone in critically ill patients.
4.3	Strategies for optimizing and minimizing risks of EN: protein vs peptides[45]	Based on **4 level 2 studies**, when initiating enteral feeds, we **recommend** the use of whole protein formulas (polymeric)	**Downgraded:** Based on **5 level 2 studies**, when initiating enteral feeds, the use of whole protein formulas (polymeric) **should be considered**.
5.5	Strategies to optimize the delivery of EN: threshold of gastric residual[95,96]	NA as new section in 2013	There are **insufficient data** to make a recommendation for specific gastric residual volume threshold. Based on **1 level 2 study**, a gastric residual volume of either 250 or 500 mL (or somewhere in between) is acceptable as a strategy to optimize delivery of EN in critically ill patients.
5.6	Strategies to optimize the delivery of EN: discarding gastric residuals[101]	NA as new section in 2013	There are **insufficient data** to make a recommendation to return gastric residual volumes up to a certain threshold in critically ill adult patients. Based on 1 level 2 study, refeeding GRVs up to a maximum of 250 mL or discarding GRVs may be acceptable.
6.2	EN (other): probiotics[46-57]	There are **insufficient data** to make a recommendation on the use of prebiotics/probiotics/synbiotics in critically ill patients.	**Upgraded:** Based on **3 level 1 and 20 level 2 studies**, the use of probiotics **should be considered** in critically ill patients.
6.5	EN: other formulas: ß HMB[102]	NA as new section in 2013	There are **insufficient data** to make a recommendation of ß HMB supplementation in critically ill patients.
7.2	Early vs delayed supplemental PN[12]	NA as new section in 2013	We **strongly recommend** that early supplemental PN and high IV glucose **not be used** in unselected critically ill patients (ie, low risk patients with short stay in ICU). In the patient who is not tolerating adequate EN, there are **insufficient data** to put forward a recommendation about when PN should be initiated. Practitioners will have to weigh the safety and benefits of initiating PN in patients not tolerating EN on an individual case-by-case basis.

(continued)

Table 1. (continued)

#	Section/New Trials	2009 Recommendation	2013 Recommendation
9.2	Composition of PN: type of lipids[62-65]	There are **insufficient data** to make a recommendation on the type of lipids to be used in critically ill patients receiving PN.	**Upgraded:** When PN with IV lipids is indicated, IV lipids that reduce the load of omega-6 fatty acids/soybean oil emulsions **should be considered**. However, there are **insufficient data** to make a recommendation on the type of lipids to be used that reduce the omega-6 fatty acid/soybean oil load in critically ill patients receiving PN.
9.4a	Composition of PN: glutamine supplementation[34-44]	Based on **4 level 1 studies and 13 level 2 studies,** when PN is prescribed to critically ill patients, parenteral supplementation with glutamine, where available, is **strongly recommended.** There are **insufficient data** to generate recommendations for IV glutamine in critically ill patients receiving EN.	**Downgraded:** Based on **9 level 1 studies and 19 level 2 studies,** when PN is prescribed to critically ill patients, parenteral supplementation with glutamine **should be considered**. However, we **strongly recommend** that glutamine **NOT be used in** critically ill patients with shock and multiorgan failure (refer to section 9.4 b). There are **insufficient data** to generate recommendations for IV glutamine in critically ill patients receiving EN.
9.4b	Combined parenteral and enteral glutamine supplementation[8]	NA as new section in 2013	Based on 1 level 1 study, **we strongly recommend that** high dose combined parenteral and enteral glutamine supplementation **NOT be used** in critically ill patients with shock and multiorgan failure.
10.4b	Optimal glucose control: carbohydrate restricted formula + insulin therapy[103]	NA as new section in 2013	There are **insufficient data** to recommend low carbohydrate diets in conjunction with insulin therapy for critically ill patients.
11.2	Supplemental antioxidant nutrients: parenteral selenium[8,40,67-72]	There are **insufficient data** to make a recommendation regarding IV/PN selenium supplementation, alone or in combination with other antioxidants, in critically ill patients.	**Upgraded:** The use IV/PN selenium supplementation, alone or in combination with other antioxidants, **should be considered** in critically ill patients.
12.0	Vitamin D[104]	NA as new section in 2013	There are **insufficient data** to make a recommendation for the use of Vitamin D in critically ill patients.

Source: Adapted from www.criticalcarenutrition.com.
ALI, acute lung injury; ARDS, acute respiratory distress syndrome; EN, enteral nutrition; GRV, gastric residual volume; HMB, hydroxyl methyl butyrate; ICU, intensive care unit; IV, intravenous; NA, not applicable; PN, parenteral nutrition.

and with the addition of the data from these, the effect on mortality decreased from relative risk (RR) = 0.67, 95% confidence interval (CI) = 0.51, 0.87, $P = .003$, heterogeneity $I^2 = 0\%$ to RR = 0.84, 95% CI = 0.56, 1.26, $P = .39$, heterogeneity $I^2 = 61\%$ (see Figure 1). There were concerns about the adequacy of the control group in 1 large multicenter study[11] in which patients received significantly more protein. Patients in this study were also randomized to a separate intervention[10] comparing low vs full EN in a 2 × 2 factorial design plus the intervention was given via boluses which may have affected the absorption of fish oils/borage oils/antioxidants.[33] When a sensitivity analyses was done without this study, the use of enteral fish oils/borage oils/antioxidants was associated with a significant reduction in 28 day mortality (RR = 0.68, 95% CI = 0.52, 0.88, $P = .004$, heterogeneity $I^2 = 0\%$). The 2 multicenter studies that reported on ventilator associated pneumonia[11,30] found no significant differences between the groups. There were significant reductions in ICU length of stay and duration of ventilation; however, the presence of statistical heterogeneity was significant. The Grau-Carmona study was the first

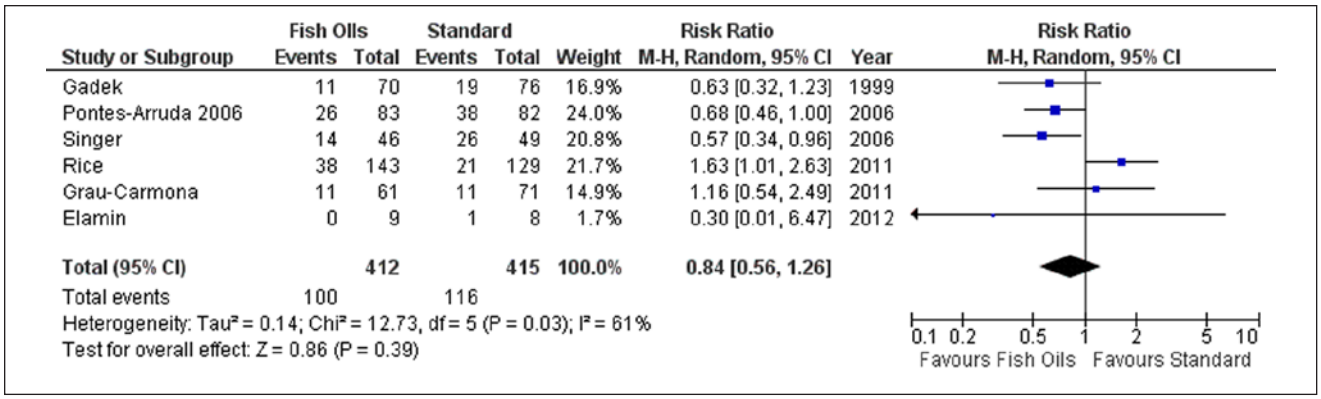

Figure 1. Effect of enteral formula with fish oils, borage oils and antioxidants on mortality (n = 6). CI, confidence interval; M-H, Mantel-Haenszel. Refer to www.criticalcarenutrition.com for more details.

large, multicenter trial that used a "usual care" control solution and the results were negative. As a consequence of the diminished signal of effect, the committee downgraded the recommendation for the use of enteral fish oils/borage oils and antioxidants from a "recommend" to "should be considered."

Compared to Placebo, Does Combined Enteral and Parenteral Glutamine Supplementation Result in Improved Clinical Outcomes in Critically Ill Patients?

There was 1 recently published multicenter study that compared glutamine via the combined enteral and parenteral route to placebo in 1223 mechanically ventilated adult patients with at least 2 organ failures.[8] Glutamine was administered early in the disease course at high doses (0.35 g/kg/day of glutamine intravenously and an additional 30 g/day enterally) for 28 days. In addition, in a 2 × 2 factorial design, patients were randomized to receive high dose selenium intravenously and vitamins and minerals administered enterally or placebo. Glutamine supplementation was associated with a trend toward an increase in 28-day mortality (32.4% vs 27.2%, $P = .05$) and significantly higher hospital mortality (37.2% vs 31%, $P = .02$) and 6-month mortality (43.7% vs 37.2%, $P = .02$) compared to no glutamine. In addition combined glutamine was also associated with significant increases in median time to discharge alive from the ICU (17.1 vs 13.1 days, $P = .03$) and the median time to discharge alive from the hospital (51.0 vs 40.1 days, $P = .04$) but had no effect on infectious complications or ventilator associated pneumonia. The committee was concerned about the increased mortality seen across all time points with the use of combined glutamine in this largest trial published to date, and hence a strong recommendation against its use was made for patients with shock and multiorgan failure. Given the unique methodology of this trial, that is, high dose glutamine combined via the enteral and parenteral route and the inclusion of more severely ill patients that were enterally underfed, the committee agreed not to include this study with other studies of parenteral glutamine or enteral glutamine supplementation.

Compared to Standard PN, Does Glutamine-Supplemented PN Result in Improved Clinical Outcomes in Critically Ill Patients?

There were 11 new RCTs comparing supplementation with parenteral glutamine to no glutamine supplementation in critically ill adults.[34-44] When the data from these trials were aggregated with those of the previous 17 RCTs in this area, there were weaker signals for a reduction in overall mortality (RR = 0.88, 95% CI = 0.75, 1.03, $p = 0.10$, heterogeneity $I^2 = 0\%$ in 2013 vs RR = 0.71, 95% CI = 0.55, 0.92, $P = .008$, heterogeneity $I^2 = 0\%$ in 2009) and infectious complications (RR = 0.86, 95% CI = 0.73, 1.02, $p = 0.09$, heterogeneity $I^2 = 43\%$ in 2013 vs RR = 0.76, 95% CI = 0.62, 0.93, $P = .008$, heterogeneity $I^2 = 28.3\%$ in 2009) and yet a strong treatment effect of IV supplemented glutamine on hospital mortality and ICU and hospital length of stay remained. It was further noted that a few large scale multicenter randomized trials of IV glutamine had failed to demonstrate a convincing positive effect.[40,43,44] The committee agreed that although the largest multicenter trial,[8] which used combined enteral and parenteral glutamine supplementation at high doses, should not be included in this section, the results from this trial could not be ignored. Coupled with a diminished signal of benefit and a potential increase in harm, the committee downgraded the recommendation for parenteral glutamine from "strongly recommended" to "should be considered," with a caution of "strongly recommend that glutamine NOT be used in critically ill patients with shock and multiorgan failure." Although there were no new RCTs of enteral glutamine supplementation, the committee also agreed to add a strong caution for the use of enteral glutamine in all critically ill patients with shock and multiorgan failure in light of the results from the recent multicenter study that showed harm with the use of combined enteral and parenteral glutamine.[8]

Does the Use of Peptide-Based Enteral Formula, Compared to an Intact Protein Formula, Result in Better Outcomes in the Critically Ill Adult Patient?

With the addition of the data from 1 new RCT[45] there was no change in the effect of peptide-based formulas on clinical or nutrition outcomes. The trend toward a reduction in hospital length of stay was based on sparse data from 2 RCTs with statistical heterogeneity (weighted mean difference [WMD] = −7.46, 95% CI = −22.35, 7.43, P = .33, heterogeneity I^2 = 91%). The committee noted that there was no evidence of a treatment effect with respect to clinical outcomes to give a recommendation for 1 product over another; however, given the higher cost of peptide-based formulas, there was agreement to make a weak recommendation for the use of polymeric products, in general. This recommendation was downgraded from "recommend" to "should be considered" for the use of whole protein/polymeric formulas to be consistent with other content areas that have no evidence for superiority based on evidence and recommendations are based on values such as safety and costs, and so on. The committee also noted that peptide-based formulas may be considered for their other components, that is, fat content, medium-chain triglycerides, glutamine composition, and so on and that patients with gastrointestinal complications (short bowel syndrome, pancreatitis, etc) may benefit from peptide-based formulas, but in the absence of positive effects on clinical outcomes, this did not result in a recommendation for these formulas.

Does the Addition of Probiotics to Enteral Feeding Result in Better Outcomes in Critically Ill Patients?

A total of 12 RCTs were added to the 2009 summary of evidence[46-57] and when the data from these trials were aggregated with the earlier trials, there was now a trend toward a reduction in ventilator associated pneumonia with the use of probiotics and a modest treatment effect of reducing overall infections (RR = 0.82, 95% CI = 0.69, 0.99, P = .03; test for heterogeneity P = .05),[58] whereas previously there was no effect (RR = 0.89, 95% CI = 0.68, 1.17, P = .40, heterogeneity I^2 = 44%). However, these estimates of effect are sensitive to the quality of the primary trials, and this reduction in infections disappeared when only high-quality studies were considered. The committee agreed that the interpretation of the earlier PROPATRIA trial,[59] which showed increased harm with the use of probiotics, was confounded by the concomitant use of fiber and jejunal feeding. With the exception of Saccharomyces boulardii,[60] a recent mega-synthesis showed that probiotics are not associated with increased risk.[61] Based on this, the committee agreed to upgrade the recommendation for the use of probiotics from "insufficient data" to "should be considered."

Does the Type of Lipids in PN Affect Outcomes in the Critically Ill Adult Patient?

In 2009 the committee was concerned about the lack of a clear signal toward a benefit in clinical outcomes and hence a recommendation was not made for the type of parenteral lipids. Since there, there have been 4 new RCTs[62-65] and the committee noted that all the trials compared a lipid strategy aimed at reducing the overall omega-6 fatty acid load (or soybean oil sparing strategy) to a soybean emulsion product. Overall omega-6 reducing/soybean sparing lipids were associated with a trend toward a reduction in mortality (RR = 0.83, 95% CI = 0.62, 1.11, P = .20, heterogeneity I^2 = 0%), duration of ventilation (WMD = −2.57, 95% CI = −5.51, –0.378, P = .09, heterogeneity I^2 = 25%), and ICU length of stay (WMD = −2.31, 95% CI = −5.28, 0.66, P = .13, heterogeneity I^2 = 68%),[66] although there were no direct comparisons of the types of lipids (ie, omega-3, omega-9, or medium chain triglyceride emulsions) to each other. This analysis lacked statistical precision, however, given the potential harm from soy bean emulsions and benefit from a strategy using an alternative lipid source, the committee agreed that in the event PN lipids are indicated, lipids that reduce the overall load of omega-6 fatty acids ought to be utilized. The recommendation was therefore upgraded from "insufficient data" to "IV lipids that reduce the load of omega-6 fatty acids/soybean oil emulsions should be considered." In addition, the committee concluded that were insufficient data to make a recommendation on the type of lipids to be used that reduce the omega-6 fatty acid/soybean oil load in critically ill patients receiving PN, given the lack of head-to-head trials of different emulsions.

Does Parenteral Selenium Supplementation (Alone or in Combination With Other Antioxidants) Result in Improved Outcomes in the Critically Ill Patient?

With the evidence from 7 new trials[8,40,67-71] there was a significant treatment effect of selenium supplementation with respect to reduced infections (RR = 0.88, 95% CI = 0.78, 0.99, P = .04, test for heterogeneity I^2 = 0%; see Figure 2) compared to the earlier evidence from 2009 (RR = 0.93, 95% CI = 0.70, 1.23, P = .61, test for heterogeneity I^2 = 0%). The trend toward a reduction mortality seen in 2009 disappeared, and this remains unchanged after the exclusion of 1 small study that had poor methodological quality.[72] The committee expressed concern regarding the heterogeneity in the trial designs, patient populations, and dosing ranges in the critically ill population. Subgroup analyses suggested that high dose selenium monotherapy with a bolus administration may have the greatest treatment effect, but these subgroup results are inconclusive given the lack of statistical precision. Given the signal of reduced infections, the committee felt that there was sufficient

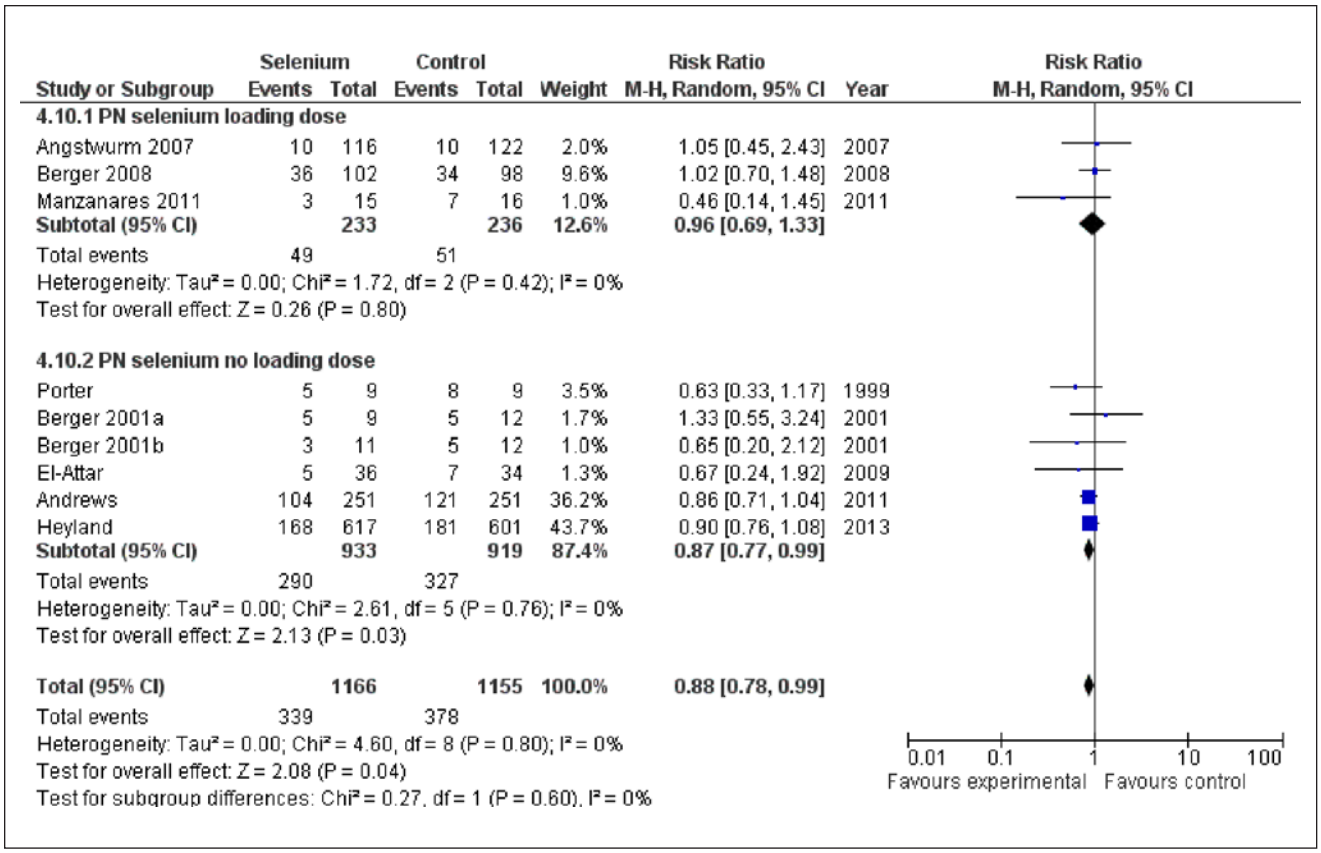

Figure 2. Effect of parenteral selenium supplementation on infections (n = 9). CI, confidence interval; M-H, Mantel-Haenszel. Refer to www.criticalcarenutrition.com for more details.

evidence to upgrade the recommendation for the use of IV/PN selenium supplementation from "insufficient data" to "should be considered."

Other Topics

The recommendations for the following topics did not change with the addition of the data from new studies: EN vs PN; early vs delayed nutrition; use of indirect calorimetry vs predictive equations; diets supplemented with arginine and select other nutrients; high protein vs low protein; fiber; small bowel feeding vs gastric; combination PN and EN; parenteral branched chain amino acids; insulin therapy; and combined vitamins and trace elements. For more details on these sections, refer to our website.[27] There were no new RCTs for the following sections and hence the recommendations did not change from 2009: achieving target dose of EN; enteral ornithine ketoglutarate; high fat/low carbohydrate; low fat/high carbohydrate; pH; enteral feeding protocols; motility agents; body position; closed vs open system; continuous vs other methods of enteral administration; gastrostomy vs nasogastric feeding; PN vs standard care; parenteral zinc (alone or in combination with other antioxidants); dose of PN; parenteral use of lipids; and parenteral mode of lipid delivery.[27]

The latest evidence in critical care nutrition as outlined in the updated CCPGs has implications for current practices in ICUs and needs to be adopted by practitioners in a timely manner to assist them in making sound decisions to optimize patient outcomes.

Key Strategies to Implement the CCPGs

The updated CCPGs were published online in January 2013 and presented at the A.S.P.E.N. Clinical Nutrition Week meeting in February 2013, but their availability to the bedside practitioner in this manner is not sufficient to fulfill their purpose of "assisting practitioner and patients decisions about appropriate health care for specific clinical circumstance."[15] To influence decision making at the bedside, active guideline implementation strategies should be adopted.[73] Over the past 20 years there have been >235 studies evaluating the effectiveness of various guideline implementation strategies.[74] The impacts of traditional dissemination and implementation activities such as journal publications and educational meetings have been found to be modest and small, respectively.[74] In addition, the effectiveness of these strategies varies across different clinical conditions, settings, and organizations.[74] Consequently, to better understand this complex process, researchers have looked to

Table 2. Knowledge-to-Action Gaps in Critical Care Nutrition.

Guideline Recommendation	Nutrition Practice Indicator[105]	Average Practice	Best Achievable Practice
EN should be used in preference to PN.	% patients receiving EN	69	100
EN should be initiated early (24-48 hours following admission to ICU)	% of patients with EN initiated within 48 hours	72	100
An evidence-based feeding protocol should be used	Feeding protocol in use in the ICU	81% of ICUs	Feeding protocol in use
In patients who have feed intolerance (ie, high gastric residual volumes, emesis) a promotility agent should be used	% of patients with high gastric residual volume receiving promotility drugs	68	100
Small bowel feeding should be considered for those select patients who repeatedly demonstrate high gastric residual volumes and are not tolerating adequate amounts of EN delivered into the stomach	% of patients with high gastric residual volume receiving small bowel tubes	12	100
Patients receiving EN should have the head of the bed elevated to 45 degrees	Mean head of bed elevation (degrees)	32	55
Hyperglycemia (blood sugars >10 mmol/L) should be avoided	% of patients glucose measurements >10 mmol/L (excluding day 1; fewest is best)	16	2
NA	% mean proportion of prescribed calories received	62	100

EN, enteral nutrition; ICU, intensive care unit; NA, not applicable; PN, parenteral nutrition.

theories of behavior change to explain how and why practitioners adopt guideline recommendations and to inform the development of more impactful guideline implementation interventions.[75] The knowledge-to-action model developed by Graham et al includes a knowledge creation component consisting of 3 phases (1) knowledge inquiry (eg, RCTs), (2) knowledge synthesis (eg, meta-analyses), and (3) knowledge tools/products (eg, CPGs) and an action cycle.[76] The 7 steps of the action cycle were derived from commonalities among 31 planned action theories and frameworks. These steps are (1) identify the problem and/or review and select the knowledge to be implemented, (2) adapt knowledge to the local context, (3) assess barriers to knowledge use, (4) select, tailor, and implement an intervention, (5) monitor knowledge use, (6) evaluate outcomes, and (7) sustain knowledge use. Although the authors presented the model as sequential steps, they conceptualized that some steps may occur simultaneously and that the knowledge creation phases may influence the action phases at any point in the cycle.[76] We will use experiences implementing the CCPGs as an illustrative example of how this knowledge-to-action model can be operationalized in the "real world." However, the steps and strategies described herein can be applied to any clinical setting or patient population.

Following the publication of the updated CCPGs, the first step is to identify if a problem exists by measuring the degree to which current practice is compliant with or deviates from the guideline recommendations. Several strategies may be employed to perform this analysis depending on the study population, location, and time frame. In the hospital setting, chart audits involving review and assessment of documented care in a patients' medical record are frequently used.[77] One of the biggest challenges of conducting chart audits is identifying objective and quantifiable measures that accurately reflect the care provided. Validity, reliability, sensitivity, clinical relevance, and the ease with which data can be obtained are some of the key attributes required for such "quality" or "performance" indicators.[78] To evaluate the guideline–practice gap, these indicators must be compared to guideline recommendations.[78] Table 2 outlines the CCPG recommendations and associated quality indicators pertaining to the provision of EN in the ICU. Since 2007, biannual international audits of nutrition practices in ICUs known as the International Nutrition Survey have been conducted.[13,14] This quality improvement initiative offers an opportunity for critical care practitioners to compare their nutrition practices to guideline recommendations and other ICUs, thereby identifying problems that need addressing. Participants are asked to enroll a consecutive sample of 20 critically ill mechanically ventilated adult patients who remain in the ICU for a minimum of 3 days. Data are collected on baseline admission characteristics, the type and amount of nutrition received each day up to a maximum of 12 days or until death, or ICU discharge. In addition, patients are followed and ICU and hospital outcomes are documented at 60 days. At the end of the audit cycle, participants receive a 28-page report that outlines their results, benchmarked against the guideline recommendations, all other participating ICUs from their geographic region, and all ICUs in the database. These data help ICUs identify areas of nutrition practice

where performance is high and areas where improvement is required. Across the 4 audit cycles it has been consistently observed that despite high adherence to some recommendations, large gaps exist between many recommendations and actual practice in ICUs (Table 2). In the most recent audit cycle in 2011 involving 183 ICUs from 27 countries, adherence to CPG recommendations was observed to be high for the following recommendations: use of EN in preference to PN, glycemic control, lack of utilization of arginine-enriched enteral formulas, delivery of hypocaloric PN, and the presence of a feeding protocol. However, significant practice gaps have been identified for other recommendations. Average time to start of EN is 40 hours (site average range: 8-152 hours). The average use of motility agents and small bowel feeding in patients who had high gastric residual volumes is 68% (site average range: 0%-100%) and 12% (site average range: 0%-100%), respectively. There is also poor adherence to recommendations for the use of enteral formulas enriched with fish oils, timing of supplemental PN, and avoidance of soybean oil based parenteral lipids. Consequently, on average the delivery of nutrition therapy is suboptimal, with patients receiving only 62% (site average range: 15%-102%) of the calories that they are prescribed (D. Heyland, MD, MSc, unpublished data, 2011). The observation of these guideline–practice gaps at both the global and individual ICU site level supports the need for actively taking steps to implement the CCPGs. However, prior to developing such a guideline implementation intervention, the barriers that may potentially hinder the proposed changes in practice must first be identified.

Assessing Barriers

Evaluating the barriers to guideline adherence is an integral part of the guideline implementation process.[79] Barriers can be any factor that may impede the implementation of change in practice. A barriers assessment may employ quantitative and qualitative methods, including observation, focus group discussions, interviews, surveys of practitioners, and analysis of the organization or system.[76] To better understand the barriers to adhering to CPGs in general and the CCPGs specifically, multiple case studies in 4 ICUs in Canada were conducted,[80] which included semistructured interviews with 28 critical care practitioners (ie, physicians, registered nurses, and registered dietitians). The main barriers identified were resistance to change, the characteristics of the critically ill patient, lack of awareness, information overload, paucity of evidence supporting the guidelines, resource constraints, a slow administrative process, a recommendation advocating a complex procedure, nursing workload, and limited critical care experience. In addition, the analysis resulted in the development of a framework for understanding adherence to critical care nutrition guidelines, which proposes that barriers can be categorized into 5 thematic domains (PERFECTIS, ClinicalTrials.gov identifier: NCT01168128):[81]

1. Guideline characteristics: Guidelines consisting of complex statements that are difficult to interpret, or are based on outdated or weak evidence, are barriers to adherence.
2. Implementation process: Lack of adequate resources in terms of time to plan, conduct, and attend educational sessions prohibits effective implementation of changes and consequently is a barrier to adhering to them in practice.
3. System characteristics: The wider economic and political context may hinder local change. At the institutional level, small, nonteaching hospitals in rural locations with an open ICU structure (ie, any attending physician can admit to the ICU) are institutional barriers to guideline adherence. Resource constraints (eg, staff, materials, specialty services) and a slow administrative process are additional barriers to adherence. A negative ICU culture, lacking leadership, lacking a cohesive multidisciplinary team structure, and poor communication are also barriers to adherence.
4. Provider intent: Lack of intent to adhere to the guideline may translate into the behavior of not adhering to guideline recommendations and is therefore a significant barrier. A provider's lack of intent is a consequence of inadequate knowledge of, and negative attitudes toward, the guidelines. Inadequate knowledge is a function of unfamiliarity and unawareness of the guideline recommendations. A negative attitude is a function of poor outcome expectancy (ie, belief that following the recommendation will not benefit the patient), lack of self-efficacy (ie, belief that one does not have the skills to implement the recommendation), lack of motivation (ie, unwilling to change), or disagreement with the guideline recommendations.
5. Patient characteristics: Guideline adherence may be more difficult in patients with a poor prognosis or for whom there are other more urgent care priorities.

Although developed for the critical care context, this framework may be a useful starting point for researchers and practitioners wishing to conduct barrier assessments in other settings or for other guidelines. To extend its practical application, this framework was used as a template to develop a 26-item questionnaire to assess barriers to the provision of EN in the ICU. An advantage of this questionnaire over other forms of barrier assessments (eg, interviews, focus groups) is that it can be distributed to all critical care physicians, registered nurses, and registered dietitians to ascertain the perceptions of a larger sample with a shorter time commitment involved for the respondent. In addition, the questionnaire focuses on modifiable barriers that are amenable to change through an intervention. As part of the 2011 audit cycle of the International Nutrition Survey, 70 of the participating ICUs also completed a barriers assessment using this novel questionnaire (D. Heyland, MD,

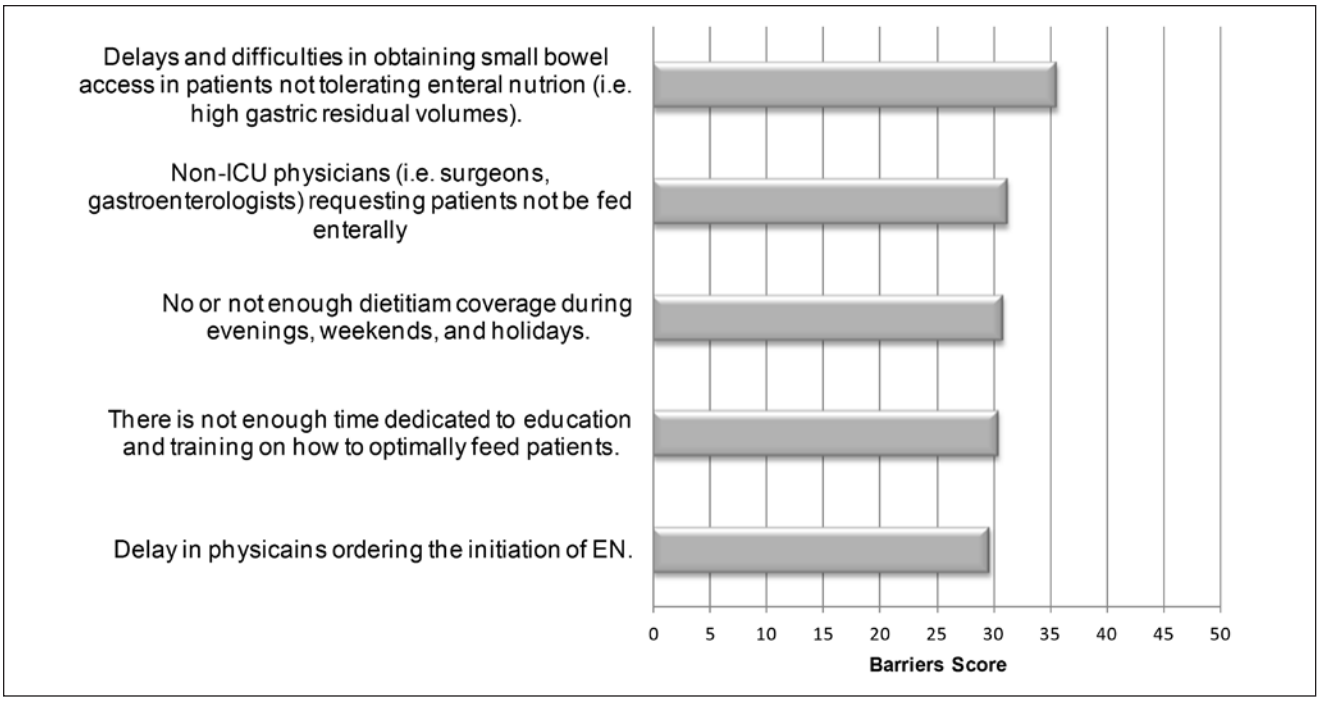

Figure 3. Top 5 ranked barriers to the provision of enteral nutrition. Barriers scores were calculated by awarding 1, 2, or 3 points if the respondent identified an item as a "somewhat important," "important," or "very important" barrier, respectively (5, 6, or 7 on the 7-point Likert-type scale). If an item was rated 1-4 (ie, "not at all important" to "neither important nor unimportant"), it was awarded 0 points. The barriers score was calculated by dividing the awarded points for each item by the maximum potential points (ie, 3) and multiplied by 100.

MSc, unpublished data, 2011). The top ranked barriers were (1) delays and difficulties obtaining small bowel access in patients not tolerating EN, (2) non-ICU physicians (eg, surgeons, gastroenterologists) requesting patients not be fed enterally, (3) no or not enough dietitian coverage during evening, weekends, and holidays, (4) not enough time dedicated to education and training on how to optimally feed patients, and (5) delays in physicians ordering the initiation of EN. Furthermore, using these data it was recently demonstrated that a barrier score (derived from responses to this questionnaire) is inversely associated with the proportion of prescribed calories received (see Figure 3), providing evidence that the presence of these barriers negatively affects the provision of nutrition.

The purpose of prospectively identifying barriers is to inform the selection of specific change strategies to address them—so-called tailored interventions.[82] In parallel with the growing interest in understanding the barriers to guideline implementation, there has been an increase in the conduct of tailored interventions. A Cochrane systematic review of tailored interventions published in 2005 identified 15 RCTs;[83] the update published in 2010 identified 11 additional studies plus 14 ongoing studies to be included in a future update.[82] The majority of the 26 completed trials involved the prescribing behavior of primary care physicians and none targeted nutrition guidelines. The results of these studies were mixed both across and within trials; some reported statistically significant improvements in all outcomes, while others observed no effect; adjusted odds ratios (ORs) at follow-up ranged from 1.07 (95% CI = 0.76, 1.49) to 12.25 (95% CI = 7.22, 20.77). The pooled OR for the 12 studies that reported a binary outcome was 1.54 (95% CI = 1.16, 2.01, $P < .001$). In addition, the authors conducted several subgroup analyses to identify attributes of the tailored intervention associated with its effectiveness. None of the investigated attributes (ie, methods of identifying barriers, level of tailoring, complexity of the intervention, use of theory) were found to be significantly associated with the effectiveness of the intervention, leading the authors to conclude that although there is some evidence to support the effectiveness of tailored guideline implementation interventions, there is inadequate information to provide specific guidance on the best methods of identifying and prioritizing barriers, or selecting interventions likely to overcome them.[82]

Given the complexity of the tailoring methodology, the PERFormance Enhancement of the Canadian Nutrition Guidelines by a Tailored Implementation Strategy (PERFECTIS) study (ClinicalTrials.gov identifier: NCT01168128) was conducted to evaluate if the tailored approach is feasible in the critical care setting. Guided by the knowledge-to-action model,[76] 5 participating North American hospitals audited their nutrition practice as part of the International Nutrition Survey and completed a barriers assessment using the newly developed barriers questionnaire. Following this 6-month preimplementation phase, the tailored intervention was developed by key stakeholders (eg, ICU manager, nurse manager, intensivists, registered dietitians,

Table 3. Questions Considered When Developing a Tailored Intervention.

- What can we do better? That is, which guideline recommendations did we perform poorly on in the practice audit?
- What are the barriers to following these guideline recommendations; that is, as indicated by the staff responses to the barriers survey?
- What barriers do we want to target for change?
- What action can we take to overcome these barriers?
  - Is this feasible in our ICU?
  - Will it result in the desired change (ie, impact of the action on the barrier)?
- What steps need to be taken to achieve this change?
  - Who will be responsible for each step?
  - When will each step be completed?
  - How will we know if the desired change has occurred (ie, outcome measure)?
  - What method should we use to assess the outcome?

registered nurses, clinical educators) attending a 1-day brainstorming meeting. The purpose of the meeting was to identify areas of nutrition practice to target for improvement, prioritize the barriers hindering current performance, and brainstorming strategies to overcome the barriers. Specifically, attendees were asked to discuss and address the questions outlined in Table 3. The selection of strategies was based on consideration of the feasibility of implementing the proposed change and the impact that this change would have on the provision of EN. To facilitate this process attendees were provided with a taxonomy for linking change strategies with barriers (see the supplemental material for this article online). The development of this taxonomy was guided by a barriers framework,[81] reference to an existing taxonomy,[84] evidence of the effectiveness of the change strategy, and input from critical care and nutrition experts. The product of the 1-day brainstorming meeting was a detailed action plan of how the changes in practice were going to be made over the 12-month implementation phase. An integral component of the implementation phase were monthly meetings to discuss progress, identify concerns and brainstorm solutions, and ensure that sites were still working toward creating change. All 5 sites successfully completed all aspects of the study demonstrating that the tailored approach is feasible.[85] However, the degree of implementation of the intervention varied across sites, with no ICU completely implementing all proposed strategies within the 12-month implementation phase. Although this study was not powered to evaluate differences in outcomes, a statistically significant 10% (site range: −4.3% to −26.0%) decrease in overall barriers score, and a nonsignificant 6% (site range: −1.5% to 17.9%) increase in the proportion of prescribed calories received following implementation of the tailored intervention was observed. Anecdotally, factors that appeared to facilitate change were the dietitian being an active member of the ICU Team (eg, attending daily rounds), support of ICU management, and embedding the change into the system. Examples of strategies adopted by sites that aided in embedding the change into the system included incorporation of feeding initiation orders as part of the ICU admission order set, a bedside algorithm for progressing and monitoring EN, and nurses able to prescribe motility agents for high gastric residual volumes. This adaptation of the guidelines to the local context is also an important step in the action cycle of the knowledge-to-action model.[76]

A System-Level Quality Improvement Intervention

While in some instances it may be important to tailor prospective interventions to local ascertained barriers, problems with deficient or outdated feeding protocols were common in many ICUs. It was previously observed that of the ICUs participating in the International Nutrition Survey, those who have such a feeding protocol in place have higher nutrition performance compared to those with no protocol to guide feeding.[86] However, the content of these feeding protocols varies across ICUs,[86] and historically they promote starting EN at a low rate and escalating gradually to the target rate. Furthermore motility agents and protein supplements are usually initiated only after intolerance or deficiency is detected. As a result, the provision of EN remains suboptimal despite the implementation of feeding protocols. Consequently, a novel protocol that includes strategies to enhance the delivery of EN proactively with the following key components was developed: (1) Starting feeds at higher initial target rate based on increasing evidence that gradual rate increases are not necessary in all patients.[87,88] (2) Shifting from an hourly rate target goal to a 24-hour volume goal and giving nurses guidance on how to make up this volume if there was an interruption for nongastrointestinal reasons.[89] (3) Initiating "trophic feeds" (ie, 10 ml/hr of concentrated EN solution designed to maintain gastrointestinal structure and function) for patients who are deemed unsuitable for high volume intragastric feeds. A recent, large-scale trial[90] has shown that this approach is safe and effective. (4) Using a semielemental enteral formula as a "safe-start" to maximize the likelihood of tolerance, absorption, and assimilation, compared to a polymeric solution.[91] The initial semielemental formula can be replaced with a standard polymeric formula if there is no intolerance. (5) Given the importance of protein intake in critically ill patients,[92] prescribing protein supplements at initiation of EN to prevent the protein debt accumulation that can occur

because of inadequate delivery of EN. (6) Starting motility agents prophylactically at the same time as start of EN with a reevaluation in the days following, based on the evidence that shows motility agents improve gastric emptying and tolerance to EN[93] and nutrition adequacy if given empirically.[94] And (7) gastric residual volumes of 250-500 mls given recent evidence that higher residual volumes can be tolerated without adverse effects in a select group of patients.[95] Despite the recent study that challenges whether monitoring gastric residual volumes is really required at all,[96] local sites were allowed to adapt this portion of the protocol to a higher level if it is consistent with their local practice patterns as long as it is 250-500 ml. This is consistent with the recent, updated Canadian critical care nutrition guidelines.[27]

A cluster RCT of this innovative nurse-driven feeding protocol involving 18 sites was recently completed.[97] It was demonstrated that this PEP uP protocol coupled with a nursing educational intervention was safe and resulted in significant improvements in nutrition practice.[97] Sites that implemented the PEP uP protocol experienced larger protein and energy increases compared to a control group (14% increase for protein [P = .005] and 12% for energy [P = .004]). In addition, the use of the PEP uP protocol was associated with a trend toward a decrease in the average time from ICU admission to start of EN compared to the control group (40.7-29.7 hours vs 33.6-35.2 hours, P = .10). Complication rates were no different between the 2 groups. The PEP uP protocol is an example of a system-level initiative that can cause significant improvements to nutrition delivery.

Identification of the guideline–practice gaps, local adaptation, barriers assessments, and tailored intervention are only some of the "steps" advocated in the knowledge-to-action model;[76] the remaining steps of monitoring and evaluating outcomes and sustaining the change are often overlooked but are equally as important a component of guideline implementation. Monitoring and evaluating the change usually involves reauditing nutrition practice, the results of which can inform whether existing change strategies need to be reinforced or whether new barriers have arisen that need to be addressed with new interventions; and thus the cycle continues. The International Nutrition Survey is an example of an initiative which aims to support the ongoing evaluation of nutrition practice. ICUs who participate in subsequent cycles of this survey demonstrate improvements in their performance.[98] The quality improvement activities of participating sites are supported through the website www.criticalcarenutrition.com, which includes a "toolkit" of educational and bedside materials such as PowerPoint presentations, templates for feeding algorithms and protocols, information sheets, and so on.

Conclusions

Given the rapidly evolving nature of nutrition literature in the critically ill adult and the potential for nutrition therapy to affect outcomes both positively and negatively, to be helpful for practitioners, it is imperative for clinical practice guidelines to be updated. The latest recommendations from the CCPGs will likely have an impact on current nutrition practices in the ICU, particularly as they are systematically and successfully implemented in ICUs around the world.

Guidelines and guideline implementation strategies must be tailored to their point of use at the bedside. Unlike a kettle that will boil water regardless of where it was manufactured, the location where it is plugged in, or who presses the "on" button, the effectiveness of guideline implementation strategies is not uniform across settings and providers. The success of guidelines, although developed by national committees of experts, depends on local innovation. Guideline implementation is an ongoing process involving targeting guideline–practice gaps, integrating the guideline into the local system, assessing barriers, implementing change strategies, and evaluating the change. Together, these steps will hopefully enable the integration of best evidence into practice leading to improvements in nutrition performance so that patients' chances of a good outcome are optimized.

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