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SYMPOSIUM

"One More Thing to Think about..." Cognitive Burden Experienced by Intensive Care Unit Nurses When Implementing a Tight Glucose Control Protocol

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Abstract

Critically ill patients require intensive nursing care. Intensive care unit (ICU) nurses, who care for these physiologically unstable patients, are continuously occupied with the integration of assessments, monitoring, and interventions that are responsive to a patient's evolving state. Since 2005, numerous evidenced-based clinical protocols have been implemented in the critical care unit. Individually, each may not appear to be burdensome but, collectively, these clinical protocols add to the cognitive work of ICU nurses. While nurses are central to the successful implementation of these protocols, little is written about the cognitive burden imposed on them by the addition of these clinical protocols. This article explores the impact of clinical protocols on the cognitive burden of ICU nurses, using a tight glucose control (TGC) protocol as an exemplar case. Research from management, ergonomics, systems engineering, and nursing is used to build the concept of cognitive burden. Future research can build upon this understanding to facilitate successful implementation of clinical protocols.

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Introduction

In 2001, investigators in Leuven conducted a large clinical trial and reported a significant decrease in mortality by maintaining "tight" blood glucose control (TGC, 80–110 mg/dl) in the surgical critically ill.[1] This was quickly adopted in many critical care units across the globe. However, subsequent studies failed to replicate the stellar results in different intensive care unit (ICU) populations.

In 2009, the Normoglycemia in Intensive Care Evaluation and Survival Using Glucose Algorithm Regulation study demonstrated an unacceptable high rate of hypoglycemia. The Society of Critical Care Medicine called for a tolerance for higher "normal" blood glucose levels (150 mg/dl versus 110 mg/dl) for patients with sepsis.[2,3] A thorough review of benefits and disadvantages of TGC is beyond the scope of this article, but can be found elsewhere.[4-6] Briefly, the discrepancy of results between these studies can be attributed to different definitions of the ideal blood glucose target, different ICU populations, and different study protocols (see **Table 1**).

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Abbreviations: (ICU) intensive care unit, (TGC) tight glucose control

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Table 1.
Methodological Differences between Tight Glucose Control Studies[a]

• Different target ranges
• Different routes for insulin administration
• Different types of insulin infusion pumps
• Different sampling sites
• Different types of instruments for blood glucose measurement
• Different nutritional strategies
• Varying levels of expertise with the therapy among the intensive care nurses

Note: Protocol compliance seldom reported.
[a] Adapted from Van den Berghe.[5]

An equally important reason for the discrepancy in results may rest in the experience of nurses and their expertise in implementing the study protocol. Compared with the Leuven trials, Van den Berghe noted that fewer patients in studies that reported no benefits remained on target with the blood glucose set point.[5] We now know that maintaining normal glucose levels has primarily benefited surgical patients.[1,4,6,7] The American College of Physicians guidelines discourage "intensive insulin therapy" in ICU patients, primarily because of the high risk of hypoglycemia.[7] However in all the studies on TGC, there is little mention if the efficacy of implementation had any effect on the results of the therapies reviewed—was patient monitoring and nursing staff involvement adequate?

Tight Glucose Control as a Nurse-Implemented Protocol

Maintaining an optimal range of blood glucose for an ICU patient requires frequent blood sampling, bedside (or laboratory) blood glucose monitoring, and a protocol to decide on the resultant dose of insulin to be administered to the patient.[8] Regardless of the debate on the optimal glucose target for a specific ICU patient population, the two common ICU nurse-related elements in any TGC protocol remains: frequent blood glucose measurements (up to hourly measurements) and careful adjustment of intravenous insulin doses. These elements ensure the responsiveness of the patient to therapy and the prevention of hypoglycemic episodes.[9] A survey of nurses on their attitudes towards TGC showed that nurses are willing to implement the protocol; while at the same time, they acknowledge the time burden.[10] Obstacles that result in deviation from the TGC protocol and its implementation include the complicated nature of the protocol and extensive efforts needed in communicating with physicians and determining the rate of insulin infusion.[10,11] Because little has been written about the cognitive burden associated with the use of bedside protocols, TGC is used here as an exemplar case.

The Nurse is Central to Successful Implementation of Clinical Protocols

The work of an ICU nurse is continuous and responsive; the ICU nurse assesses, measures, and documents hemodynamics, oxygenation, and ventilation parameters, titrates sedation and vasoactive medications, provides physical care, and attends to the concerns of the patient's family.[10] The ICU nurse is central to the care delivered to the patient; the nurse coordinates the patient's care during his hospitalization and collaborates with other clinical staff.[12]

Although most clinical protocols are interdisciplinary, requiring physicians, pharmacists, physical therapists and nurses to work together, the ICU nurse remains central to successful implementation of clinical protocols in the ICU because they are the only discipline at the bedside 24/7. In a spontaneous breathing mechanical ventilation trial, nurses were used in the protocol as early identifiers of eligible patients.[13] Nurses played an important role in monitoring patients as well as in successful conduct of clinical protocol research.[13,14] In a survey of ICU protocols, Prasad[15] highlighted the centrality of the ICU nurse in clinical protocols by defining a protocol as one that "allows a nurse to evaluate the patient and change the therapy accordingly."[15] In all protocols surveyed by Prasad, for example, sedation during mechanical ventilation and early goal-directed therapy for sepsis, the ICU nurse was among the top two drivers of the protocol. The second top drivers included trainees (residents and/or fellows) and respiratory therapists.

Cognitive Burden and the ICU Nurse

The role of the ICU nurse is crucial to the success of clinical protocols. It is therefore timely to explore the concept of cognitive burden, or the mental task performed by an ICU nurse in processing information and managing a patient with a clinical protocol. Most of the nursing literature on nursing work and/or workload focus on peripheral factors related to the environment (physical work environment, ergonomics), organization (job satisfaction, empowerment, autonomy), emotional

job strain, and nursing characteristics (knowledge, work experience, skill set). However, here we add to the literature by focusing on one particular work characteristic: cognitive or mental burden borne by ICU nurses caused by clinical protocols as they render care for patients. Approaching nursing workload using the perspective of cognitive burden provides a framework in developing and planning future protocols that will not only hypothetically result in improved care, but also potentially enhance nursing's work.

The ICU Nurse as Knowledge Worker

Peter F. Drucker, a founding father of organizational management, coined the term "knowledge work" in 1959 to represent the development of the evolution of work in companies.[16] Work was no longer viewed as a collection of monotonous tasks, but people instead had to use their intellect to gather information and use knowledge in their work. Drucker[17] envisioned industries to be information driven, rooted in relevance and purpose. He likened them to hospitals where individuals, or knowledge workers, are specialized and use their knowledge to guide their own work. The ICU nurse is such a worker, using his training and skills to manage the care of a critically ill patient. When using a TGC protocol, the ICU nurse uses feedback from the monitoring of the patient's blood glucose and his knowledge to stop, decrease, maintain, or increase doses of insulin. Yet this is not the only aspect of the work of the ICU nurse with regards to the protocol.

Components of Cognitive Burden with Respect to Protocols

The concept of cognitive burden in the clinical setting is significantly different from general mental workload literature, as research in that area is based on having one primary task and investigating the workload of a secondary task, in this case, the clinical protocol.[18] However, nursing care in the ICU is variable depending on the needs of the patient. It could be argued that the basics of airway, breathing, and circulation are components of the primary task, but that would be an extremely simplistic view of the critically ill. Aragon[10] acknowledges the presence of added cognitive complexity of a TGC protocol. An ICU nurse implementing a TGC protocol will not just be administering and monitoring blood glucose levels, but also taking into consideration the circumstances and condition of the patient that will affect his glucose response, such as the presence of parenteral nutrition, course of illness, past responses, and the need for steroid, catecholamine administrations, and dialysis.

Decision Making

The ICU nurse is confronted with many glucose values. The data, or blood glucose levels, now need to be converted into information using the existing knowledge of the ICU nurse.[10] One of the problems of decision making is simplification.[19] Protocols can also be seen as a simplified way of decision making—get a glucose level, exclude extraneous factors, give insulin, remeasure, and readjust. However, protocols can be unsafe when the decision maker is not anchored with reason and knowledge and neglects rigorous questioning of the patient's condition and response.

It is possible that a protocol can decrease the cognitive burden of the ICU nurse. In a simulation of low or medium complexity tasks, aircraft pilots were able to prioritize their work with less mental effort when they learned to apply preset rules or stored mental patterns during training sessions to make decisions.[20] However, this was not seen in complex situations. This suggests that well crafted protocols can decrease the cognitive burden of the ICU nurse, but this may not be possible when the ICU nurse is caring for a highly complex patient.

Situated Cognition

Expert decision making in critical care requires situated cognition. Situated cognition is thinking linked with the action during an unfolding situation.[21] However, Benner and colleagues[21] introduced the uncertainty of the situation, which could add to the cognitive burden borne by the ICU nurse. When using the TGC protocol, the ICU nurse reasons in a constantly changing and evolving situation of the patient. Benner and colleagues[21] rightly suggested that there is an open-endedness in the patient's situation because the patient's health and ICU condition is a continuum. In a tactical flight training simulator setting, Svensson and colleagues[22] found that, when compared to novice pilots, expert pilots were able to integrate more complex data while maintaining flight in a certain altitude on real-life terrains. These objective measures correlated with subjective ratings of cognitive workload by the pilots.[22] Similarly, in the TGC protocol, the blood glucose level has to be interpreted in context of the current, possibly physiologically

complex state of the patient when that data was obtained. Svensson and colleagues study suggests that this interpretation might be easier for expert nurses than for less experienced nurses. In contrast, Gregg[23] reported no significant relationship between education, experience, and subjective cognitive burden in a sample of 70 cardiovascular critical care nurses. However, these responses were collected only after 4 hours of work and included nurses who had ≥6 months of critical care experience,[23] and were without the addition of a clinical protocol.

Human Mental Workload

Human mental workload is well discussed in engineering psychology literature and is based on control theory. Mental workload is used to investigate how individuals, such as fighter pilots, work through highly stressed environments. The individual is termed a metacontroller. This term shows the complexity of juggling perception, decisions, and prioritizations that go through the metacontroller's brain. Henry R. Jex, an engineering psychologist, defines mental workload as the "operator's evaluation of the attentional load margin (between their motivated capacity and the current task demands) while achieving adequate task performance in a mission-relevant context."[24]

Winwood and Lushington[25] note that mental work demand includes having to concentrate on many things at the same time—calibrating, giving correct medication, and monitoring. Their study of 760 Australian nurses showed that psychological work demand was more predictive than physical work for poorer levels of sleep, fatigue, and recovery. However, in their analysis, psychological work included mental load, emotional load, peer and supervisor problems. Regardless of the broad definition of psychological work, the study itself demonstrates that mental load at work plays a role in the health and wellbeing of nurses.

Thinking Associated with Work is Social

Congruent with the aforementioned comments, thinking rooted in a situation is reiterated by Jex's concept on human mental workload. Jex states that the workload problem is multifaceted, as situations, time, and psycho-physiological aspects such as experience and fatigue have to be taken into account. Thinking that is associated with work is social; it does not exist in isolation, but rather in a community, and in a context. Jex names three dominant factors, or context of the workload. They are busyness, complexity, and consequences.[19] Thus, the protocol itself, can lend to "intrusiveness", interrupting the primary ICU caring task, adding complexity and busyness to the patient's care, increasing the mental workload. Ideally, incorporating the protocol into the routine ICU caring tasks can reduce its intrusiveness and reduce mental burden on the ICU nurse. In his discussion on the implementation of TGC in the ICU, Schultz[26] states that a "social investigation" is warranted prior to application so as to ensure success.

Ways to Limit Cognitive Burden from Protocols

There remains a question on whether a protocol is actually a miniature assembly line of instructions, a routine that removes the need to think. Thinking and making judgment in the ICU require humans, and therefore involve human factors. Chase and colleagues[27] list the human factors that affect TGC protocol implementation. Many of these factors are visible to the naked eye, for example, administrative load, work flow in the ICU, and collaboration. One of the factors, "clinical burden", includes effort. This effort could also include the nurse's nonvisible cognitive burden or effort in protocol. The thinking in clinical burden is similar to that discussed in situated cognition and human mental workload.[27] The concept of clinical cognitive burden encourages us to improve the synchrony between protocol and implementation, with the ICU nurse as the principal care deliverer. Anchoring the ICU nurse with the physiological reasoning behind the TGC protocol and the factors that might confound the blood glucose data in a critically patient will improve the nurse's decision-making. Fear, discomfort, and lack of experience in managing an insulin infusion are reasons given for nonadherence to the TGC protocol.[9,28] Nurses are generally enthusiastic in using the protocol when they understand the rationale and potential benefits.[28,29] Nurses are also enthusiastic when the need to call physicians is lessened.[29] Chase and colleagues suggest that the computerization of a protocol aids in removing cognitive processing that might be required to interpret paper-based protocols. However, Chase and colleagues also acknowledge that this could work against compliance because explanations about the process are not frequently provided within a computerized algorithm, which might discourage nurses from following the protocol. Vogelzang and coworkers[8,30] and Davidson and colleagues[29] describe a computer algorithm developed for TGC protocol in various ICU populations. The success of the computerized protocol was attributed to the nurse's involvement in design, ownership, and application.[29]

Clinically, the computer algorithm took into consideration the common variables that would affect glucose levels (catecholamines, steroid administration, and enteral nutrition) and reminded the nurses when the next blood glucose measurements were due. This helps reduce cognitive burden of having to think about the timing of the next glucose values. However, even with the computerized algorithm, the nurses were given the opportunity to revoke the algorithm, which would have involved cognitive work for the nurses. The requirement of cognitive work reiterates the need for ICU nurses to be grounded in the knowledge of the pathophysiology of glucose metabolism in the critically ill to make these decisions with the least cognitive burden. Thompson and colleagues[31] evaluated the implementation of a computerized protocol in a multicenter study involving six adult ICUs and five pediatric ICUs.[31] Despite the high percentage of accepted instructions (93%) of the protocol and low hypoglycemia rates (0.18%), target glucose values (70–110 mg/dl) were met only 48% of the time. This could be attributed to the wide glucose monitoring interval of 2 h in the protocol. The 21 nurses randomly surveyed reported that the electronic protocol was easy to use, did not affect other nursing activities related to the patient on the protocol or other patients in their care, and did not add to their work-related stress but was just as time consuming as managing mechanical ventilation or a single vasoactive medication. These nurses had an average of 6 years working experience and had used the protocol on an average of six patients.

Situated cognition and human mental workload imply that increased nursing experience aids in less cognitive workload, that thinking that is associated with work is not isolated but needs clinical community support. Boulkina and Braithwaite[32] acknowledge that "complex intuitive care" of nurses is irreplaceable by a good protocol, but instead a "carefully engineered protocol potentially can improve upon the intuition of highly skilled nurses." Less experienced ICU nurses may require a clinical nurse specialist and ICU community support during protocol implementation. Similar to clinical experience, situatedness of cognition is continual in the clinical setting and all clinicians will require continued knowledge development in their fields.

Real-life clinical examples of how the protocol is implemented, while allowing the ICU nurse to ask questions, also assist in situated cognition.[33] Incorporating the protocol into routine ICU care also reduces clinical cognitive burden as it reduces busyness and complexity. Harper[34] stressed that making the protocol simple and the "right" and the easy thing to do is essential for both safety and efficacy, but it is also important not to streamline protocols with too many assumptions, such that finer details are lost and safety is compromised.[35] A summary of recommendations are listed in **Table 2**, and hypothetical protocol-patient scenarios and their impact on clinical cognitive burden are listed in **Table 3.**

Conclusion

This article explores the impact of clinical protocols on the cognitive burden of ICU nurses, using a TGC protocol as an exemplar case. However, this discussion can be extended to other clinical protocols. Literature from engineering, management, and critical care nursing informs us of the importance of anchoring the ICU nurse with knowledge and clinical rationale, and providing a supportive clinical environment to place thinking into context and situation. Coupled with a well-designed computerized algorithm, reducing clinical cognitive burden in nurses will lead to better practice and, in turn, to successful implementation of the protocol and improved patient outcomes. In clinical settings with limited computer and technological support, paper protocols will require rigorous structure, clarity, and more intensive grounding and education to facilitate protocol integration. Research on anchoring and supportive techniques will provide an evidence-based approach to future clinical protocol implementation. This is important

Table 2.
Components of Cognitive Burden and Ways to Limit Them

Components	Ways to limit cognitive burden
Decision making	• Anchoring nurse in rationale for TGC • Reviewing the pathophysiology of glucose metabolism in ICU population • Protocol is straightforward
Situated cognition	• Provide real life exemplars of TGC implementation • Synergize nursing expertise with patient complexity • Continuing education on advances in the field
Mental workload	• Provide emotional and peer support • Use a protocol that is the "right" and "easy" thing to do
Socialness of thinking	• Provide clinical nurse specialist/ Experienced staff support • Incorporate the protocol into routine ICU care

Table 3.
Patient-Protocol Interactions and Their Impact on Cognitive Burden

	Scenario 1	Scenario 2	Scenario 3
Protocol elements	• Paper system • Recommends rate of continuous insulin & intermittent bolus dose depending on most recent value. • Nurse must call prescriber for any change in insulin dose. • Glucometer shared between several patients.	• Computerized system • Protocol algorithm takes into account caloric intake. • Calculates time to next glucose sampling based on value trends. • Standing orders facilitate rapid insulin titration. • One glucometer per patient.	• Computerized system • Protocol algorithm takes into account patient health history, insulin dose needs prior to admission, caloric intake, patient on catecholamines and dialysis. • Calculates time of next glucose sampling based on value trends. • Standing orders facilitate rapid insulin titration.
Patient characteristics	• Mechanically ventilated, T2DM patient on oral hypoglycemic agents prior to admission, requires intravenous steroids daily for spinal injury.	• Mechanically ventilated, on continuous enteral nutrition via PEG tube post operative after head and neck cancer surgery.	• Mechanically ventilated, T2DM patient on insulin prior to admission, requiring continuous renal replacement therapy, on inotopic support in acute cardiac failure.
Guideline	• Maintain blood glucose 80–110 mg/dl.	• Maintain blood glucose 80–110 mg/dl.	• Maintain blood glucose 80–110 mg/dl.
Cognitive burden	• ICU nurse has to determine the frequency of blood glucose measurements during and after steroid infusion, taking into consideration the patient's changing condition.	• Less cognitive burden as most of patient's symptoms are included in the algorithm. • Built-in reminders. • The ICU nurse is grounded with the knowledge of pathophysiology and the principles of the protocol algorithm and will be able to question the recommendations at any time.	• Less cognitive burden as most of patient's history and symptoms are included in the algorithm. • Built-in reminders. • The ICU nurse is grounded with the knowledge of pathophysiology and the principles of the protocol algorithm and will be able to question the recommendations at any time.

PEG, percutaneous endoscopic gastrostomy; T2DM, type 2 diabetes mellitus

because ICU nurses need fewer things to think about.

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