**Perioperative Glucose Control**

**What Is Enough?**

TYPE 2 diabetes mellitus, impaired fasting glucose/impaired glucose tolerance, and stress-induced hyperglycemia (SIH) are ubiquitous in the adult population and represent major public health concerns. Almost 10% of adult Americans have type 2 diabetes mellitus, an additional 20–25% have impaired glucose tolerance/impaired fasting glucose, and an unknown number develop SIH. Upwards of one third of affected patients are unaware of the presence of dysglycemia and its systemic effects. Projections predict a continued, dramatic increase in the incidence and prevalence of type 2 diabetes over the next several decades, with its deleterious impact on quality of life and life expectancy. In this issue of *Anesthesiology*, Drs. Lipshutz and Gropper address the impact of dysglycemia on perioperative management.

Patients with diabetes require acute and critical care, procedural interventions, and hospitalizations more commonly than those with normal glucose tolerance. When patients with diabetes require hospitalization or undergo certain procedures, they sustain greater morbidity and mortality. Studies from this decade have shown that a minimalist approach to glucose control in selected perioperative and critically ill patient populations is unwarranted, and improved glucose control leads to less morbidity and better outcomes, particularly in those with SIH. Key questions remain unanswered. How tight should glycemic control be? Are all hyperglycemic patients at equal risk for morbidity and mortality?

The effectiveness of controlling glucose, and recognize mortality in intensive care unit patients using intensive insulin therapy to provide TGC be interpreted with care in light of risks reported when this approach is applied universally. They comment on the potential differences in glucose control and outcome related to type 1 versus type 2 diabetes or SIH, the effect of glucose variability during the course of intense monitoring and therapy, and the current risk-benefit data on TGC in various populations. They caution about extrapolating intensive care unit studies directly to the perioperative patient. We would go a step further and caution against a sudden call for intraoperative normalization of blood glucose (80–110 mg/dL; 4.4–6.1 mmol). Additional data should be obtained before implementing rigid perioperative standards of glucose management while tying reimbursement for care of the hyperglycemic perioperative patient to potentially unsubstantiated goals.

This thorough review briefly comments on the importance of glucose monitoring, quality control of bedside glucose measurements versus laboratory techniques, and attempts at developing continuous and closed loop systems to control glucose. The reliability of glucose measurements is important to remember when controlling glucose levels during the dynamic perioperative period. Practical pitfalls in glucose monitoring secondary to sample site and source, technique of monitoring, impact of concurrent pathophysiologic states and interfering substances such as nonglucose sugars, and various medications are now recognized.

The source of glucose monitoring, point-of-care device, blood gas analyzer, or central laboratory evaluation may explain some of the conflicting results reported when intensive insulin therapy and TGC protocols are instituted.

Point-of-care glucose monitoring using finger-stick capillary blood, the most common approach to perioperative evaluation, is based on application of ambulatory technology using photoreflectometry or electrochemical reaction. The Food and Drug Administration mandates a ± 20% agreement between the point-of-care device and laboratory gold standard. Differences between laboratory and point-of-care–derived values are particularly important in intensive care unit patients who are anemic, hypothermic, or hypoperfused. Potentially critical disagreements between the central laboratory value and point-of-care measurement may lead to inappropriate insulin management. Certain operative patients, particularly those in shock or actively hemorrhaging, are likely to be affected.

Multidisciplinary teams should develop glucose control protocols, set reasonable goals for control, monitor the effectiveness of controlling glucose, and recognize...
and carefully monitor patients at high risk for hypoglycemia.\textsuperscript{14–17} The latter is especially important during the perioperative period, when early signs of hypoglycemia may be masked due to the administration of sedatives, analgesics, and anesthetics. The University of California, San Francisco group and others have reported their success with such an approach.\textsuperscript{14–17} Nonetheless, given concerns over reports of hypoglycemia with intensive insulin therapy that range from 5–18.7% and increased mortality when hypoglycemia (glucose < 40 mg/dL; 2.2 mmol) develops in critically ill patients, cautious application of TGC in the perioperative period should be the norm until more data are forthcoming.\textsuperscript{4,5,18,19} Further, the effort and resources required to maintain TGC are significant, and the potential for long-term morbidity secondary to hypoglycemia-induced neuropsychologic compromise has not been well studied.

The implications of establishing practice guidelines and applying them globally\textsuperscript{17} to complex perioperative populations that range from patients with neuroischemia, neurotrauma, cardiac compromise, and sepsis, to name but a few, are significant. Adding the variables discussed in this review, prior diabetes, type 1 \textit{versus} type 2, SIH, and a host of others such as obesity, age, and other end-organ compromise further complicate the potentially premature call for routine TGC in the perioperative period. The wisdom of applying glucose management standards to pay for performance remains to be proven and can be potentially dangerous at present and should await additional data. The application of these standards might even be better to unique patients, and their use must await further study in diverse patient populations.

The Normoglycaemia in Intensive Care Evaluation and Survival Using Glucose Algorithm Regulation (NICE SUGAR) Trial\textsuperscript{20} completed enrollment of 6100 patients in August 2008.\textsuperscript{20} Although an ICU trial, it is multicareter, international, prospective, and randomized, and it is the largest trial of its kind. It has the potential to further guide therapeutic interventions in patients with a broad spectrum of illnesses, including those in the perioperative period.

The development of a prospective multi-institutional database evaluating the incidence and evidence-based management of hypoglycemia or hyperglycemia across the heterogeneous perioperative population would address some major public health concerns. This database would facilitate identification of previously undiagnosed surgical patients with diabetes, aid in determination of the incidence and natural history of SIH in perioperative patients, and provide data on the impact of glycemic management and quality of long-term care of specific subsets of patients, including those undergoing primary neurologic, cardiac, or traumatic surgery. Unfortunately, at present, other than epidemiologic screens such as the National Health and Nutrition Examination Survey,\textsuperscript{21} there is no program, federally or privately funded, available to generate such information. Hopefully, the drive for evidence-based medical care could facilitate such a vehicle to examine this and other important perioperative diagnoses and management strategies such as use of β-blockers, indication for statin administration, and application of genomic diagnostics to stratify care and optimize outcome.

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