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Convergence of Continuous Glucose Monitoring and In-Hospital Tight Glycemic Control: Closing the Gap between Caregivers and Industry

Michaela Miller, M.B.A., Matthew J. Skladany, B.S., Christopher R. Ludwig, M.B.A., and Joshua S. Guthermann, B.S.

Abstract

The convergence of continuous glucose monitoring (CGM) and tight glycemic control protocols is approaching. As with the diffusion of any innovative technology, there will be challenges that will likely delay widespread adoption. With the objective of assessing the current mindset of health care professionals toward CGM adoption in the hospital intensive care unit (ICU) setting and resulting implications to industry, Boston Biomedical Consultants surveyed >60 U.S. ICU managers and nurses during Spring 2007. The underlying sentiment expressed by survey respondents toward CGM was positive, with many citing potential benefits of CGM adoption, such as labor savings, improved glycemic control, and assistance with insulin dosing. While the demand for CGM in the hospital clearly exists, early stage product acceptance will remain limited given the substantial education, market development, and economic hurdles.

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With the parallel emergence of continuous glucose monitoring (CGM) for physician office/patient home use and tight glycemic control protocols in hospitals, the convergence of this new technology and growing inpatient care standard is approaching. While CGM designed specifically for the hospital setting has yet to reach commercialization, a significant number of manufacturers are developing products with the expectation of reaching commercialization within the next 2 to 4 years. As with the diffusion of any innovative technology, challenges are likely to delay widespread adoption. With the objective of assessing the current mindset of health care professionals toward CGM in the hospital intensive care unit (ICU) setting and resulting implications to industry, Boston Biomedical Consultants (BBC) surveyed >60 U.S. ICU managers and nurse clinicians in Spring 2007.

A growing body of scientific evidence supports the use of tight glycemic control in ICU/surgical units. Data presented in the publication of two key clinical studies by Dr. Van den Berghe *et al.* in 2001 and Dr. Furnary *et al.* in 2004 strongly suggest improved patient postoperative outcomes, such as decreased mortality, reduced incidence of deep sternal infections, and decreased length of stay.[1,2]

Author Affiliation: Boston Biomedical Consultants, Waltham, Massachusetts

Abbreviations: (BBC) Boston Biomedical Consultants, (CGM) continuous glucose monitoring, (ICU) intensive care unit, (ISF) interstitial fluid, (WBG) whole blood glucose

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Corresponding Author: Michaela Miller, M.B.A., Boston Biomedical Consultants, 1000 Winter Street, Suite 1300, Waltham, MA 02451; email address *mmiller@bostonbiomed.com*

Dr. Furnary's 2004 study stated that it was the presence of perioperative hyperglycemia, not diabetes, that was linked to higher rates of complications in patients not treated with the intensive protocol.

In addition to scientific evidence, hospital glucose monitoring product vendors have increased the availability and promotion of products supporting implementation/management, as well as education and support services, to facilitate the establishment of tight glycemic control protocols.

Given the demonstrated benefits of tight glycemic control protocols, they have become the new standard of care in ICUs across the United States; >90% of hospitals surveyed by BBC had tight glycemic control protocols in place. In nearly all instances the protocol had been implemented across the entire ICU, covering any patient exhibiting glycemic excursions regardless of diabetes disease status. Over 50% of interviewees had implemented their respective tight glycemic control protocols within the past 3 years. Additionally, select respondents reported the expanded use of a tight glycemic control protocol beyond the ICU, e.g., in step-down units, with a small percentage of hospitals implementing an institution-wide regimen.

The underlying sentiment expressed by ICU managers and nurses regarding tight glycemic control was overwhelmingly positive, despite some obvious drawbacks. Eighty percent of participants listed the additional time investment (in light of no additional human resources) as the main drawback of the recent change in standard of care. The patient discomfort of hourly whole blood glucose (WBG) testing and finger pricking was mentioned as a major drawback in 30% of cases.

The recent genesis and expanding hospital-wide use of tight glycemic control clearly suggest the need for new technologies such as CGM to mitigate the challenges imposed upon hospital staff in terms of incremental time investment and data management requirements. When asked about the potential benefits of CGM, 93% of respondents cited nurse labor savings and 24% referenced improved patient comfort. The addition of a continuous glucose monitor could significantly reduce the 2 hours of direct nursing time per patient required per day to implement a tight glycemic control protocol.[3] Additional labor savings could potentially be realized with a computer-based insulin dosing algorithm or semiclosed glucose sensing/insulin delivery system. Thirty-eight percent of respondents cited an interest in a CGM device that could provide assistance with insulin dosing, moving toward a semiclosed/closed-loop system. This seems particularly important, as insulin is among the most commonly reported products involved in ICU medication errors[4] **(Figure 1)**.

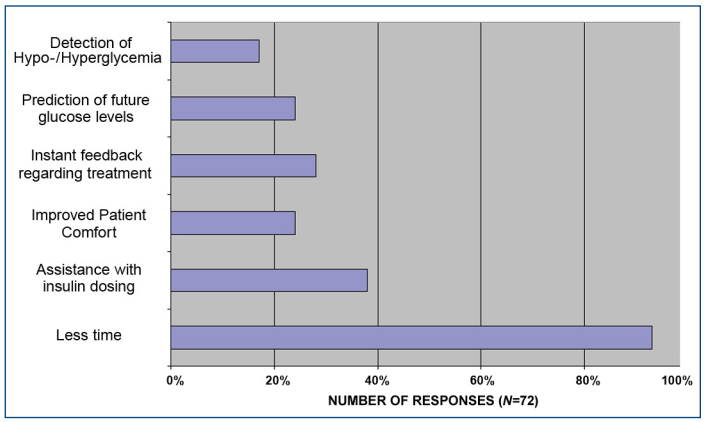

Figure 1. Perceived benefits of CGM in the ICU.

The second most frequently cited potential gain from adopting CGM in the ICU was improved inpatient glycemic control because of benefits such as

- Immediate feedback regarding therapeutic adjustments (28%)
- Predictability of glucose levels (trend data) (24%)
- Hypo/hyperglycemic detection (17%).

Nurses' fear of inducing hypoglycemia has been cited as a major impediment toward tight glycemic control adoption,[5] and studies have demonstrated that patients treated under such protocols experienced on average more episodes of hypoglycemia than conventionally treated patients.[1,6] Hypo/hyperglycemia projections and threshold detection are common features on commercially available CGM devices and would prove of equally great value in the ICU setting.

Despite the clear value added with CGM technology, caveats pertaining to its ICU adoption remain. Roughly 44% of respondents indicated that accuracy and precision of CGM technology (in relation to conventional bedside glucose monitoring products—whose accuracy has been criticized repeatedly in academia[7,8]) would have to be proven as a condition for adoption. Additionally, 31% of participants expect higher supply costs associated with CGM technology and consider it a major drawback, particularly in light of absent reimbursement. Of note, <10% of participants actually evaluated the incremental

costs associated with the implementation of tight glycemic control in their respective institution.

Finally, >50% of respondents seemed frustrated by the internal product approval process, which could easily take >9 months and would require substantial documentation related to accuracy/precision, improved patient outcomes, and patient care, as well as cost and time savings.

Results show that in light of tight glycemic control becoming the new standard of patient care, health care professionals in the ICU are ready to consider CGM technology; however, product acceptance will remain limited in the early stages given the substantial education, market development, and economic hurdles.

Industry Implications

For industry, driving adoption of such technology advancements will require (a) substantial market development (resources), (b) (existing) access to hospitals/ICUs, and (c) well-developed skills to work toward reimbursement.

As part of the required market development efforts to address one of the largest unmet needs in hospital glucose monitoring, industry has to invest in clinical trials demonstrating the accuracy of CGM technology in the ICU along with cost-benefit analyses. "If a continuous monitoring blood glucose device could be reasonably accurate, then such a device would rapidly gain wide acceptance. Nevertheless, in severely cost constrained environments […], industry should always expect the requirement for cost-benefit analyses and the necessary delays in implementation concomitant with a bureaucratic process of approval," says Dr. Stanley A. Nasraway, Chief Surgical Critical Care and Professor, Tufts Medical School and Chairman of the Sontra Medical Corporation Medical Advisory Board.

"The bottom line clinical improvement resulting from […] CGM technology will drive adoption," says Lior D. Ma'ayan, CEO of OrSense, an Israel-based company developing a noninvasive CGM system based on occlusion spectroscopy. Clinical data would not only have to address concerns about CGM accuracy and risk of infection, but also demonstrate improved patient outcomes, e.g., the avoidance of hypoglycemia. "Trending capabilities with existing technologies allow physicians to be diligent with glycemic control monitoring. Planning for intervention is an obvious superior approach compared to reacting to outdated glucose level data," says Harry Mitchell, Interim CEO of Sontra Medical Corporation, a Massachusetts-based start-up developing a CGM device based on ultrasound-mediated skin permeation technology. "The ability to intercept early hypoglycemia would give bedside clinicians greater confidence in achieving stricter blood glucose thresholds. It would also alleviate the natural anxiety that accompanies the fear of severe hypoglycemia," reinforces Nasraway.

Industry further needs to focus resources on cost-benefit analyses, evaluating incremental expense and savings related to the use of CGM in the ICU. As the research given earlier indicates and supported by the findings of Daleen Aragon, R.N., Ph.D., C.C.R.N., "costs and nursing work associated with blood sugar testing and tight glycemic control [were widely] unknown.[3]" In her study, Aragon indicates that at a level 1 trauma center in the southeastern United States, nurses conducted approximately 213 WBG tests per day. She further estimated nurses' salaries at an annual cost of $182,488, or approximately $2.35 per test. If the use of CGM could reduce the amount of glucose monitoring frequency via finger stick from eight times per day on select patients to four times per day (for calibration purposes or confirmatory tests for insulin dosing), the cost in nursing salaries associated with WBG testing could potentially be reduced by as much as 50%.

These data points, along with potential further reductions in sepsis,[9] morbidity, mortality, length of stay, and other quantifiable benefits, will have to be demonstrated by industry to drive the adoption of CGM to the point of becoming a widely accepted health care standard.

Industry access to hospitals and the availability of a strong support system as health care professionals embark on the bureaucratic process of obtaining internal product purchase approval will also be critical. The complexity of the internal review board process, which on average can take >9 months given the various decision makers involved, will delay product acceptance and likely stall motivation to start the process. Vendor support in providing the needed documented benefits may facilitate more rapid adoption of one product versus another. For smaller competitors and resource-constrained start-ups, this may present a challenge.

The third component critical to industry to facilitate broad adoption of CGM in the ICU is the support provided to institutions to obtain reimbursement. Software programs that track patient data and improved outcomes, as well as clinical studies proving long-term cost savings, will prove critical. Hospitals will need to document that the use of

CGM in conjunction with tight glycemic control shows outcomes sufficient to garner "pay for performance" from private and public health care payers. Without a question, CGM systems will bear premium pricing compared to conventional bedside glucose monitoring technologies, making such studies even more relevant.

Clearly, there will be ample challenges facing CGM adoption in the ICU once products become available commercially. While it is too early to predict which technology will dominate, it is fair to say that currently available CGM technologies are not ideal. Starting with the lag time associated with interstitial fluid (ISF)-based CGM sensors[10] to the risk of infection, ICU professionals are seeking more accommodating technologies.

"The absolute Holy Grail would be the development of a continuous blood glucose meter that is non-invasive," says Nasraway, who evaluated Sontra's transdermal CGM device at Tufts New England Medical Center in the surgical ICU. Others are looking at products to close the loop, as is the case in Norfolk, Nebraska, where Michelle D. Zwiener, M.S.N., R.N. purchased 10 Medtronic Paradigm® REAL-Time combination CSII/CGM systems to implement a tight glycemic control protocol at Faith Regional Health Services. The regimen was implemented in the ICU and hospital wards with varying feedback; pumps were only used on the wards. "The nurses outside of the ICU have responded much more favorably to the tight glycemic control protocol using the Paradigm REAL-Time. The ICU has issues with the lag time associated with ISF measurements. IV-Insulin is delivered, but staff does not see the CGMS respond right away. […] Nurses on the other floors, however, really like the trend data and hypo/hyperglycemic alarms," says Zwiener.[11] Ideally, Zwiener seeks the ability to view CGM sensor data from the nurses' station.

Among technology concerns voiced by industry, Terry Gregg, CEO and President of DexCom, highlighted the need for "CGM to measure blood glucose in the ICU given the impact on ISF from metabolytes and diuretics administered to surgical patients."

More rapid CGM acceptance may be enforced further through the consolidation of products already present in the ICU, addressing concerns about introducing another bedside monitoring device. "A glucose-only paradigm will have adoption challenges […] and be subject to pricing pressure," says Peter Rule, CEO and President of OptiScan, a privately held company located in California that is developing a multianalyte system for the ICU based on mid-infrared spectroscopy. "Glucose is necessary but not sufficient," says Rule, pointing out that a reduced incidence of infection and sepsis are the focal points for ICU physicians.

Clearly, a "one-size fits all" solution may not exist, but addressing accuracy and precision, particularly in light of the wide array of ICU medicine, will be absolutely critical. Health care professionals in the ICU say they are ready to welcome CGM as a solution to many of the challenges emerging with the implementation of tight glycemic control protocols as the new standard of care. What they need from industry is evidence/education and support to bring forward financially viable solutions that address needs specific to the ICU setting.

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