

# Development of a Computerized Intravenous Insulin Application (AutoCa/) at Kaiser Permanente Northwest, Integrated into Kaiser Permanente HealthConnect: Impact on Safety and Nursing Workload

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## Abstract

**Context:** The electronic medical record, HealthConnect, at the Kaiser Sunnyside Medical Center in the Northwest used scanned paper protocols for intravenous insulin administration. A chart review of 15 patients on intravenous insulin therapy using state-of-the-art paper-based column protocols revealed 40% deviation from the protocol. A time study of experienced nurses computing the insulin dose revealed an average of 2 minutes per calculation per hour to complete.

**Objective:** To improve patient safety and to reduce nursing workload burden with a computerized intravenous insulin calculator application connected to HealthConnect.

**Solution:** Using Kaiser iLab developers through innovation funding, a computerized protocol was developed and integrated into HealthConnect, with a computerized tracking system used to store and to analyze intravenous insulin data.

**Outcome:** A review of 35 patient charts using computerized insulin infusion tool indicated 100% accuracy in computations with a reduction of nursing workload from 2 minutes to 30 seconds per calculation.

**Conclusion:** Development and operationalizing an integrated intravenous insulin calculator into HealthConnect was successfully completed at the Kaiser Sunnyside Medical Center, with 97% nursing satisfaction scores and a promise to generate data on intravenous insulin therapy to refine the protocol.

## Introduction

The ideal blood glucose target for hospitalized patients is controversial, yet there is no controversy over the importance of glycemic control to patient outcomes.<sup>1,2</sup> Intravenous (IV) insulin is the most effective way to provide glucose control in hospitalized patients, but state-of-the-art paper column-based protocols are labor intensive and can result in errors.<sup>3</sup> Commercial computerized IV insulin programs currently do not integrate into Kaiser Permanente (KP) HealthConnect, the electronic medical record. Therefore, there is a definite need for an integrated, computerized IV insulin dose application that is easily accessed by the bedside nurse.

Stress hyperglycemia, inflammatory mediators, underlying  $\beta$ -cell failure, hyperalimentation, corticosteroid therapy, and vasopressor therapy are just a few of the contributors to hyperglycemia creat-

ing the perfect glycemic storm in hospital medicine.<sup>4,5</sup> According to the National Center for Chronic Disease Prevention and Health Promotion, diabetes affects 25.8 million Americans.<sup>6</sup> Among these US residents, 10.9 million, or 26.9% of those aged 65 years and older, had diabetes in 2010.<sup>6</sup> Medical expenses for patients with diabetes are more than 2 times higher than for those without diabetes.<sup>6</sup> Direct medical costs account for \$116 billion, and indirect costs account for \$58 billion for disability, work loss, and premature mortality.<sup>6</sup>

Diabetes and hyperglycemia are very common in hospitalized patients. Studies continue to reveal associations between uncontrolled hyperglycemia and poor outcomes in clinical conditions such as stroke,<sup>7,8</sup> myocardial infarction,<sup>9-11</sup> coronary artery bypass grafting,<sup>12-14</sup> other surgeries,<sup>15</sup> cancers,<sup>16</sup> and critical illness.<sup>17-19</sup> Although diabetes may not be the primary admitting

diagnosis, hyperglycemia is a potentially catastrophic catalyst under the stress of illness or surgery, making it a critical hospital care issue that can no longer be overlooked. Improvements in the delivery of care to patients with diabetes and hyperglycemia are therefore needed to reduce poor patient outcomes and improve efficiencies in inpatient diabetes care.

Insulin has long been the gold standard for management of hyperglycemia in the hospital, but the delay in onset and variability in absorption of injectable subcutaneous insulin can present an obstacle in the acute care setting in some clinical situations.<sup>20</sup> The fastest acting injectable analog insulins have an onset of 15 to 30 minutes, a peak of 60 to 120 minutes, and a duration of 3 to 5 hours.<sup>20</sup> Intravenous insulin is different. Intravenous insulin has a very short half-life of 5 to 7 minutes and a biologic effect of 15 to 20 minutes.<sup>21</sup> The pharmacokinetic differences allow the clinician to rapidly titrate the dose of insulin on the basis of the individual patient's sensitivity to response to insulin with hourly dose changes. The effective results of immediate and continuous IV delivery of insulin are hampered only by potential safety hazards, as insulin is one of the top 5 high-alert medications,<sup>22</sup> and by the increased workload of hourly point-of-care blood glucose testing to determine the drip rate.<sup>23</sup>

Protocol orders are considered medication orders and, as such, deviation from the protocol without a physician order is considered a medication error. With dozens of protocols to choose from, the ideal protocol is one that can be executed by nursing staff in response to a single physician order and is simple enough to compute in a reasonable amount of time

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with a low margin for error.<sup>24</sup> Currently no single protocol has proved ideal for all situations.<sup>25</sup> In fact, comparison of various published protocols has proved difficult because of variations in the definition of hypoglycemia, methods employed for blood glucose measurement, and types of blood samples used in assays as well as the wide range of patients from surgical to medical populations and the variability of nursing workloads.<sup>26</sup>

In a study by Malesker and associates<sup>27</sup> in 2007, nurses' perceptions on the impact of tight glycemic control on workload was studied. Deviations from the protocol accounted for 75% of glucose measures, averaging greater than 9 per patient. Various explanations were given for the deviation, but 2 reasons that compared with the

KP Northwest (KPNW) experience were time to calculate insulin infusion rate and the perceived fear of hypoglycemia, which gave way to adjusting the medication order without consulting a physician. In the state of Oregon, registered nurses cannot legally change medication orders independently without consulting a physician.<sup>28</sup> In addition, a physician cannot expand nursing scope of practice by directing a nurse to perform an activity that is not recognized by the nursing profession as proper to be performed by a nurse in Oregon.<sup>28</sup>

### The Kaiser Sunnyside Medical Center Experience

Kaiser Sunnyside Medical Center (KSMC), a 250-bed tertiary care community hospital in Clackamas, OR, has a very high incidence of diabetes and hyperglycemia, with the attendant challenges in inpatient management. A review of 35 paper medical charts from various units at KSMC from January to March 2006 indicated that 62% of these patients had some degree of hyperglycemia, defined as 2 fasting blood glucose levels above 140 mg/dL. Since 1995, KSMC has reaped the benefits of IV insulin therapy not only in intensive care units (ICUs) and step-down units but also on medical-surgical units. It has allowed patients to stay on the general wards while being actively treated for hyperglycemia with the precision permitted by an IV insulin protocol. Since 2007,

KSMC has used a column-based protocol, which has been periodically revised in response to targeted quality improvement chart reviews as well as changing recommendations for glycemic targets (see Kaiser Sunnyside Medical Center Insulin Infusion Protocol [target 90-140] on our Web site at: [www.thepermanentejournal.org/files/Summer2012/InsulinInfusion-Protocol.pdf](http://www.thepermanentejournal.org/files/Summer2012/InsulinInfusion-Protocol.pdf)).

The frequency of IV insulin therapy was determined using pharmacy dispensing data and verified with chart audit. IV insulin is used in 3 to 8 patients a day at KSMC, which translates into 72 to 192 insulin dose decisions made each 24 hours, or 2160 to 5760 potential chances for medication error per month. In late 2008, a review of 15 charts in which IV insulin was the therapeutic modality was conducted to determine the current efficacy and safety of the existing column-based IV insulin protocol. Surprisingly the actual protocol was difficult to evaluate because only 172 of the 262 decision points, or approximately 65%, demonstrated adherence to the protocol, from which we inferred there were frequent unintentional errors in calculating the insulin drip rate. This presented a safety concern.

The time it takes an experienced registered nurse to figure out the insulin dose was investigated. A time study, using a

video camera recording of a nurse determining the insulin rate from the paper protocol, revealed an average of 2 minutes to calculate the insulin infusion rate. For safety, the protocol requires a double check on each calculation. Therefore, in a 12-hour shift, this would translate into 24 minutes for the first nurse plus 24 minutes for the verifying nurse, for a total of 48 minutes spent on calculating the rate.

The recognition that experienced nurses spent 48 minutes each shift, with 65% accuracy, became the platform for looking for a safer and more efficient way to deliver care. In addition, KPNW began to roll out the inpatient electronic record, HealthConnect, in 2009. As the hospital changed to electronic documentation and order entry, the dilemma of managing an algorithm-based protocol necessitating computer documentation of hourly blood glucose measurements, insulin doses, and paper-column protocol became an added challenge. The paper 9-column protocol became a scanned document in HealthConnect, and there were challenges transferring patient data from the paper protocol to HealthConnect.

### Innovating a Solution

Although limited, the safety data on computerized medical decision-making programs appeared promising.<sup>29</sup> Technology

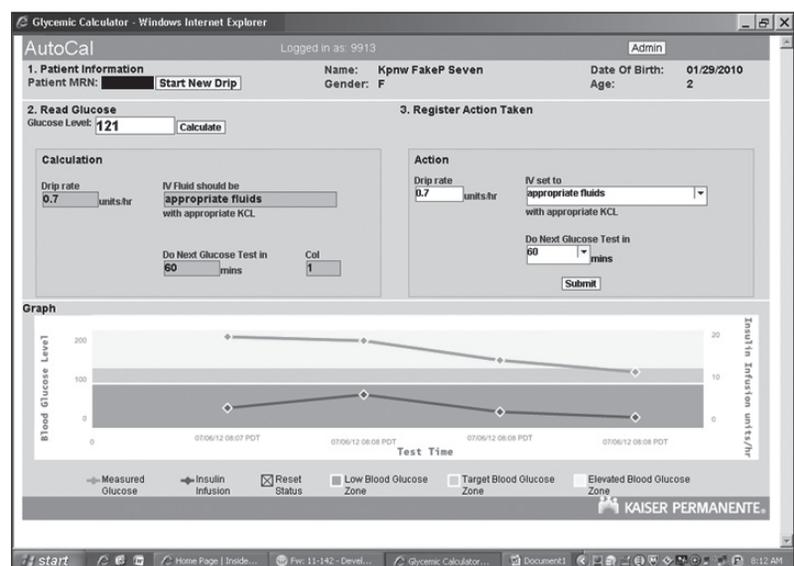


Figure 1. AutoCaI automated intravenous insulin dose calculator.

hr = hour; mins = minutes; IV = intravenous; KCL = potassium chloride; MRN = medical record number; PDT = Pacific Daylight Time.

seemed the logical solution to the repetitive compliance of following a prescribed algorithm.<sup>30</sup> Initially we looked at commercial Web-based products such as Glucommander (Glytec Systems, Greenville, SC) and EndoTool (Hospira, Lake Forest, IL) but found at that time most commercial products required the purchase of hardware and software. Integration with an electronic medical record required one computer for HealthConnect and one computer for the IV insulin program. In addition, local hospitals using these products were using IV insulin therapy only in the ICU. The sheer volume of implementing a commercial computerized Web-based product throughout KSMC was cost prohibitive.

In March 2009, we applied for and received funding from KP Information Technology Innovation Fund for Technology. Collaborating with the developers from the Innovation and Advanced Technology iLabs allowed us to translate the paper-based protocol into a Web-based application, which we nicknamed *AutoCal*. KP developers were able to rapidly prototype a Web-based calculator in 6 months, with weekly check-ins for revisions and updates based on input from staff nurses experimenting with the application. We pilot tested the use of *AutoCal* from September 2009 to December 2009 (Figure 1). *AutoCal* replaced the paper version on the cardiovascular ICU and 3 South, a medical-surgical telemetry unit specializing in caring for patients with diabetes and renal disease. These units were chosen because cardiovascular surgical patients with dysglycemia receive IV insulin therapy for at least 48 hours postoperatively, and because 3 South has a population that frequently requires IV insulin management.

At the end of the 3-month pilot test, charts were reviewed. The results were impressive, revealing 100% adherence to the protocol using *AutoCal* compared with 65% accuracy with paper (Figure 2). A follow-up time study, again using a video camera, demonstrated an average of 30 seconds per dose calculation using *AutoCal* compared with 2 minutes with the paper version (Figure 3). A nursing satisfaction survey was also administered demonstrating 87% satisfaction with the stand-alone version of *AutoCal*. When

asked what would make this tool easier to use, the overwhelming response from the nurses was to integrate the tool into HealthConnect.

The pilot test's initial success allowed funding to continue into 2010, and efforts to integrate into HealthConnect were begun. The developers programmed a "bridge" designed to launch *AutoCal* directly from the patient's chart to the insulin infusion calculator, which was completed by December 2010. A follow-up survey of nurse users demonstrated an impressive 97% satisfaction. Training of all nursing staff at KSMC was completed, and refinement of the application continued into 2011. As of October 2011, *AutoCal* has been fully integrated and is now used to calculate insulin infusion rates on every hospital unit at KSMC. Using *AutoCal* data from October 2011 forward, we can generate hospitalwide IV insulin data, which will be used to refine the tool.

### Next Steps

Currently, analysis of IV insulin therapy safety and efficacy remains a time-consuming process of manual chart review. *AutoCal* was built with the promise of electronic storage of glucose values and insulin dose changes available for faster, more rigorous data analysis. The current protocol is not logarithmic, and the application was built to allow clinicians with administrative privileges the ability to change doses to the protocol. Now KPNW is poised to make rational adjustments as needed to our current IV insulin protocol based on data from hundreds of patient-hours on IV insulin regimens. *AutoCal* will now allow us to offer patients ongoing improvements in glycemic management while continuing to give the bedside nurses tools to safely and cost-effectively deliver care.

### Conclusion

Hyperglycemia should not be treated as a casual finding in hospitalized patients. IV insulin therapy can be more safely and efficiently delivered on hospital wards with the use of computerized IV dose calculators. *AutoCal* has simultaneously increased nurse satisfaction in caring for patients with hyperglycemia who require IV insulin management. There is also the capacity to use historic data gathered from

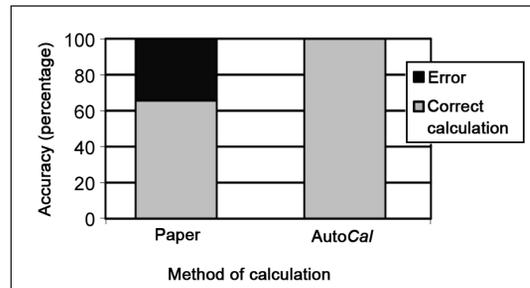


Figure 2. Comparison of accuracy between manual paper computation and computerized *AutoCal*.

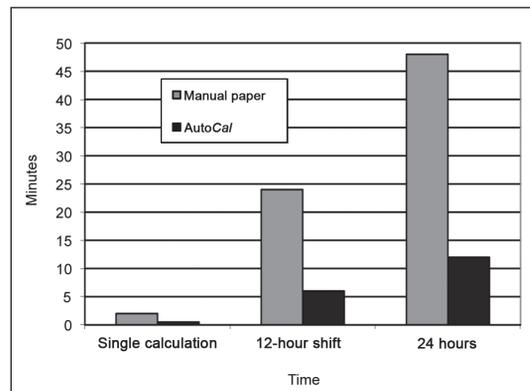


Figure 3. Observation of registered nurse time for paper-based calculation vs computerized *AutoCal* calculation.

actual runs of IV insulin infusions to continuously analyze and improve the safety and efficacy of the IV protocol. *AutoCal*, a HealthConnect-integrated IV insulin dose calculator, promises to remain an essential tool in caring for patients with hyperglycemia. ♦

### Disclosure Statement

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## Blessings of Humanity

The trained nurse has become one of the great blessings of humanity, taking a place beside the physician and the priest, and not inferior to either in her mission.

— Sir William Osler, MD, 1849-1919, physician, clinician, pathologist, teacher, diagnostician, bibliophile, historian, classicist, essayist, conversationalist, organizer, manager, and author