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# Controlling Blood Glucose Levels to Reduce Infection

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Achieving and maintaining tight glucose control in the critically ill patient is becoming the standard of care across the country. It is well established that hyperglycemia is common in critically ill patients, and recent studies have shown a possible connection between hyperglycemia and the ability to fight infection. Healthcare providers face many challenges when choosing to implement this evidence-based practice into their standard of patient care. The purpose of this article is to share one hospital's collaborative approach to tight glucose control. **Key words:** *blood sugar*, *glucose control*, *insulin therapy*

ACHIEVING and maintaining tight glucose control in the critically ill patient is becoming the standard of care across the country. It is well established that hyperglycemia is commonly seen in critically ill patients, even among those without a history of diabetes.[1] The 2001 randomized study conducted by Van den Berghe et al demonstrated that the use of intensive insulin therapy to maintain blood glucose levels at or below 110 mg/dL substantially reduced mortality in the intensive care units (ICUs), in-hospital mortality, and morbidity among critically ill patients[2] admitted to their intensive care units (ICUs). There are many challenges facing those healthcare providers who choose to implement this evidence-based practice into their standard of patient care.

The Critical Care Team at Memorial Hermann Southwest Hospital (MHSW) in Houston, Tex, took up the challenge in March 2003 as a participant in the VHA Transformation of the Intensive Care Unit (TICU) Wave III. The VHA Inc is a healthcare provider alliance of healthcare organizations. They help facilitate application and monitoring of evidence-based care.[3] The MHSW joined the VHA/TICU in 2002 as one of the original Wave I teams.

The TICU Teams were given the challenge to eliminate ventilator-associated pneumonia (VAP) in 6 months. VAP is a hospital-acquired infection thought to be caused by prolonged intubation and mechanical ventilation ($\geq$48 hours).[4,5] The "VAP Bundle," as it has come to be known, includes a list of initiatives. There have been remarkable decreases in pneumonia rates when the VAP initiatives are instituted as a unit.[3] Maintaining blood glucose levels between 80 and 110 mg/dL is one component of the bundle.

It is widely known that sepsis is closely associated with a series of inflammatory and metabolic responses,[6] and insulin is thought to have an anti-inflammatory effect on tissues, while glucose exhibits pro-inflammatory effects.[7]

With this challenge in mind, the MHSW began the arduous task of bringing glucose levels within target (80–110 mg/dL) on all mechanically ventilated patients. At the time of our initial study, the ICU consisted of four 8-bed units mixed medical/surgical beds.

## EXISTING PROTOCOLS

We began by locating existing hospital protocols.

- A hospital-wide subcutaneous insulin sliding scale order set and hypoglycemia

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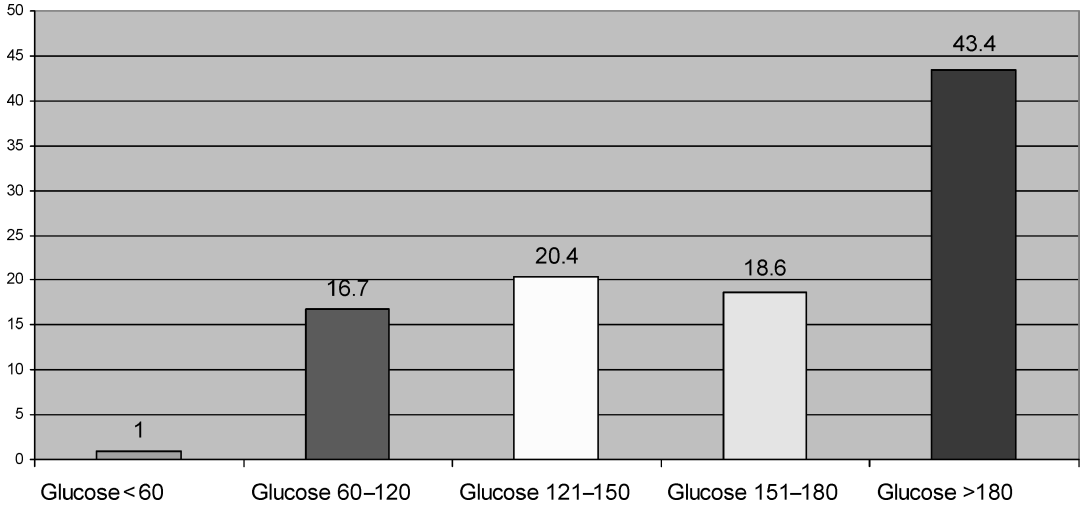


**Figure 1.** Memorial Hermann Southwest Hospital. From VHA database. (Available at: www.VHA.com/)

protocol was established in 2001. This order set provided a standard guideline for the physician when ordering sliding-scale coverage for patients with hyperglycemia.

- The insulin drip order set had been in existence since the 1980s for the treatment of postoperative coronary artery bypass hyperglycemia. The target blood glucose was set at <200 mg/dL.

## GETTING STARTED

A TICU committee was developed at our facility in 2002 to bring together a team of multidisciplinary healthcare workers. It consists of nurses, physicians, respiratory care technicians, dieticians, case managers, social workers, patient relations, environmental services, pharmacists, chaplain, and finance personnel. Meetings are held weekly to discuss and evaluate the progress of the team and to brainstorm new projects.

We began by collecting baseline glucose data to analyze existing glucose levels and corresponding sliding-scale insulin treatment (Fig 1). It showed that our existing *subcutaneous* sliding-scale was an effective tool for bringing the blood glucose levels into range. However, it was readily apparent that the insulin *drip* scale did not meet our needs because of the lack of coverage for blood glucose levels less than 200 mg/dL.

## FIRST TRIAL

We began our first trial in April 2003. The order set was long and complicated, referring to tables for infusion rate increases or decreases. The adjustments were so rigid that they did not allow for an adequate drop in milligram per deciliter, ultimately leading to prolonged time to target.

## SECOND TRIAL

After 3 months, we decided to trial another scale that was developed by a hospital in our area. It, too, was set up with tables in a grid-like style. It guided the clinician to select a dose adjustment on the basis of the patient's glucose level and trends. In addition to rate adjustments, bolus doses were included for glucose levels greater than 150 mg/dL.

We monitored this tool for 6 months, following the patients for hypoglycemic events, and length of time to target. All hypoglycemic events were audited for negative outcomes. No adverse effects were noted, possibly

## Insulin drip protocol

**Goal:** Treatment of hyperglycemia for a target blood glucose of **80–110 mg/dL**
Not for treatment of DKA

1. Discontinue **ALL** previous orders for insulin.
2. Obtain glucose Q1H after insulin infusion started. If no rate changes are needed for 3 consecutive measurements and in target range, decrease accuchecks to Q2h.
3. Resume Q1H accuchecks if TPN or enteral feeding is decreased or discontinued, made NPO for any reason, or to achieve target glucose (i.e., 80–110 mg/dL).
4. If TPN or tube feeding is restarted, resume accuchecks Q1H (See no. 2).
5. When meals are resumed, consider change to subcutaneous insulin sliding scale.

**Initiating insulin infusion (Use Novalog Insulin)**

| 150–200 mg/dL | 201–250 mg/dL | 251–300 mg/dL | 301–350 mg/dL | 351–400 mg/dL | >400 mg/dL |
|---|---|---|---|---|---|
| 2 units/h | 3 units/h | 6 units/h | 8 units/h | 10 units/h | 12 units/h |

**Initiating infusion titration (Use Novalog Insulin = 1 unit/mL)**

| | |
|---|---|
| **<60** mg/dL | Stop Insulin infusion<br>Give 1 amp D50W & recheck blood glucose in 1 h |
| **60–79** mg/dL | Stop Insulin infusion<br>Recheck blood glucose in 1 h. If greater than 80 mg/dL, restart insulin infusion at ½ the previous rate |
| **80–110** mg/dL | If previous glucose was greater than 80 mg/dL, maintain the same rate<br>If BG trending downward by 10–20 mg/dL, may decrease rate by 0.5–2 units/h<br>If previous glucose was less than 80 mg/dL, restart infusion at ½ the previous rate |

| | If trending upward more than 20 mg/dL | If trending downward more than 20 mg/dL |
|---|---|---|
| **111–150** mg/dL | Increase rate by 0.5–2 units/h | Decrease rate by 0–2 units/h |
| **151–200** mg/dL | Increase rate by 1–3 units/h | Decrease rate by 0–3 units/h |
| **201–250** mg/dL | Increase rate by 2–4 units/h | Decrease rate by 0–3 units/h |
| **251–300** mg/dL | Increase rate by 2–4 units/h | Decrease rate by 0–4 units/h |
| **301–350** mg/dL | Increase rate by 3–5 units/h | Decrease rate by 0–5 units/h |
| **350–400** mg/dL | Increase rate by 3–5 units/h | Decrease rate by 0–5 units/h |
| **>400** mg/dL | Increase rate by 3–5 units/h and notify MD | Decrease rate by 0–5 units/h |
| | Call MD for rates greater than 50 units/h | |

Signature: _____ MD

Date/time: _____

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Insulin Drip Protocol

88899 1/05

**Figure 2.** Insulin drip sliding scale protocol.

**Regimens:**

- **Low-dose regimen:** Suggested as starting point of the thin and elderly (probably type I DM).
- **Medium-dose regimen:** Suggested as the starting point for average weight (either type I DM or type II DM).
- **High-dose regimen:** Suggested as the starting point for overweight patients (probably type II DM).
- **Very high dose regimen:** Suggested as the starting point for patients with infections or those receiving steroids (probably type II DM).

| **Order** |
|---|
| **1. Please check the type of Insulin**<br>[ ] Human Regular Insulin [ ] Aspart (Novolog) |
| **2. Please check the Dose Regimen**<br>[ ] Low Dose [ ] High Dose [ ] Other<br>[ ] Moderate Dose [ ] Very High Dose |
| **3. All insulin is given subcutaneously unless otherwise specified.** |
| **4. If potassium is low (< 3.5 mEq/L), call physician.** |
| **5. Please check fingerstick blood glucose schedule.**<br>[ ] Q4H<br>[ ] Q6H (Recommended for patients who are NPO)<br>[ ] AC only<br>[ ] AC & HS (Recommended for patients WHO ARE ABLE TO EAT) |
| **6. If any reading is ≤ 60, initiate hypoglycemia protocol, and notify MD.** |
| **7. Nurse to initiate Diabetes Education Assessment.** |

| Glucose level (mg/dL) | Low-dose regimen | Medium-dose regimen | High-dose regimen | Very high dose regimen | Other |
|---|---|---|---|---|---|
| Serum FBS < 60 | Hypoglycemia protocol and call MD | Hypoglycemia protocol and call MD | Hypoglycemia protocol and call MD | Hypoglycemia protocol and call MD | Hypoglycemia protocol and call MD |
| 60–100 | 0 units | 0 units | 0 units | 0 units | units |
| 101–120 | 2 units | 3 units | 4 units | 5 units | units |
| 121–150 | 3 units | 4 units | 5 units | 6 units | units |
| 151–200 | 4 units | 5 units | 6 units | 7 units | units |
| 201–250 | 5 units | 8 units | 10 units | 15 units | units |
| 251–300 | 6 units | 10 units | 14 units | 18 units | units |
| 301–350 | 8 units | 12 units | 17 units | 21 units | units |
| 351–400 | 10 units | 16 units | 20 units | 25 units | units |
| > 400 | 10 units, call MD | 16 units, call MD | 20 units, call MD | 25 units, call MD | _____ units, call MD |
| | | | | | |
| **If >150 after 24 hours of SS insulin** | **Start insulin drip protocol** | | | [ ] Check here if you **DO NOT** want an automatic insulin drip | |

**Physician's signature**_____ **Date:** _____ **Time:** _____

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**Physician's orders**
**Sliding scale insulin**
**2/04**

Patient label here

**Figure 3.** Subcutaneous sliding scale protocol.

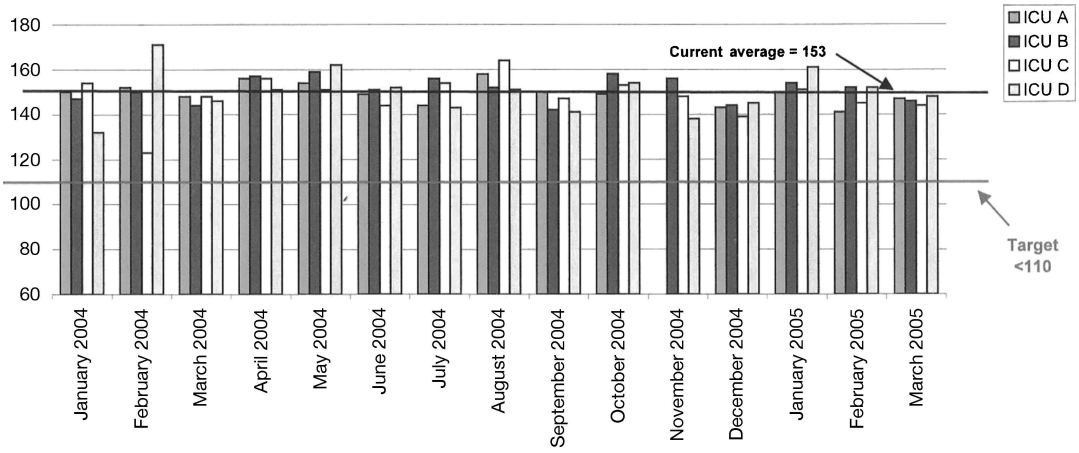


**Figure 4.** Memorial Hermann Southwest Hospital average of all blood glucose levels on all intensive care unit (ICU) patients.

because of frequent assessment (finger-stick glucose levels run every 1–2 hours).

The staff nurses were surveyed to obtain their perspective on the tool's effectiveness and ease of use. They stated that the tool was not nurse-friendly. It was wordy and difficult to read. The sliding-scale rate adjustments did not allow for critical thinking. Nurses generally have an intuitive understanding of their patients' response to treatment. There are patients who are brittle with labile blood sugar levels, whereas others require large doses of insulin to bring their blood glucose down to an acceptable level. The nurses wanted to see a tool that would allow them to determine the appropriate dose based on their knowledge of the patient while continuing to follow specific guidelines. Bolus dosing was also considered to be an additional step that was not necessary if the rate could be adjusted more aggressively.

Ultimately, we identified 2 recurring defects to the tool when followed according to the guidelines.

- For blood glucose levels > 150 mg/dL, the length of time to target ranged from 6.5 to 10 hours.
- For blood glucose levels <150 mg/dL, hypoglycemic events (blood glucose <60 mg/dL) increased.

## THIRD TRIAL

With staff nurse involvement, a third insulin drip protocol was designed (Fig 2). The focus was simplicity and nurse autonomy. In January 2005, and after 3 revisions, the new protocol was implemented housewide, replacing the postoperative CABG scale. The new tool allowed the nurse to adjust the rate according to specific guidelines, while providing flexibility for patient response. A nursing policy was written to accompany the tool to include guidelines for use of variable dosing and selection.

The tool was readily accepted by the majority of the nursing staff. They were satisfied with the ability to adjust their dosing rates in a manner that was more patient-specific.

In addition to development of the new insulin drip protocol, a revision was made to the subcutaneous scale that gave the nurse the ability to change to a drip if blood glucose levels remained more than 150 mg/dL over the previous 24 hours (Fig 3).

## PHYSICIAN BUY-IN

Physician acceptance was much more elusive. Our largest hurdle, which still exists to this day, is the fear of hypoglycemia.

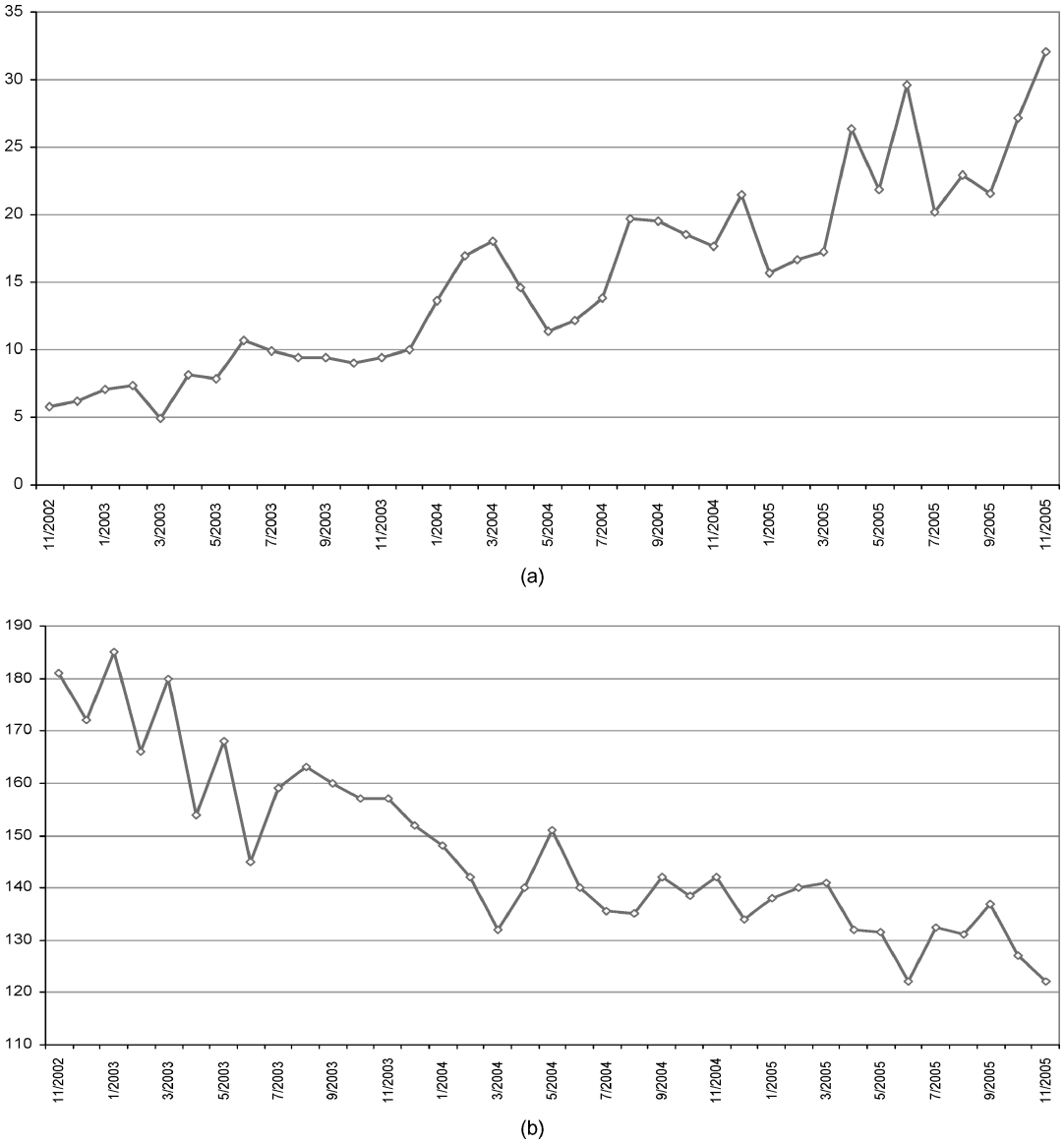


**Figure 5.** Memorial Hermann Southwest Hospital. (a) Appropriate glucose control from November 2002 to November 2005 and (b) medium glucose level samples collected at 8:00 AM daily from October 2002 to November 2005. From VHA database (Available at: www.VHA.com/).

Even when presented with the latest research, physicians tend to be skeptical about the reliability of the studies. They are not easily swayed to change their practice based on a few research articles.[8]

Much time and energy were spent educating the physicians to promote our initiative.

- The protocol and latest research studies were presented at physicians' section meetings.
- Interdisciplinary rounds were made daily (M-F). All patient blood glucose levels were assessed. Team recommendations for insulin adjustment were placed in the patient's medical record.

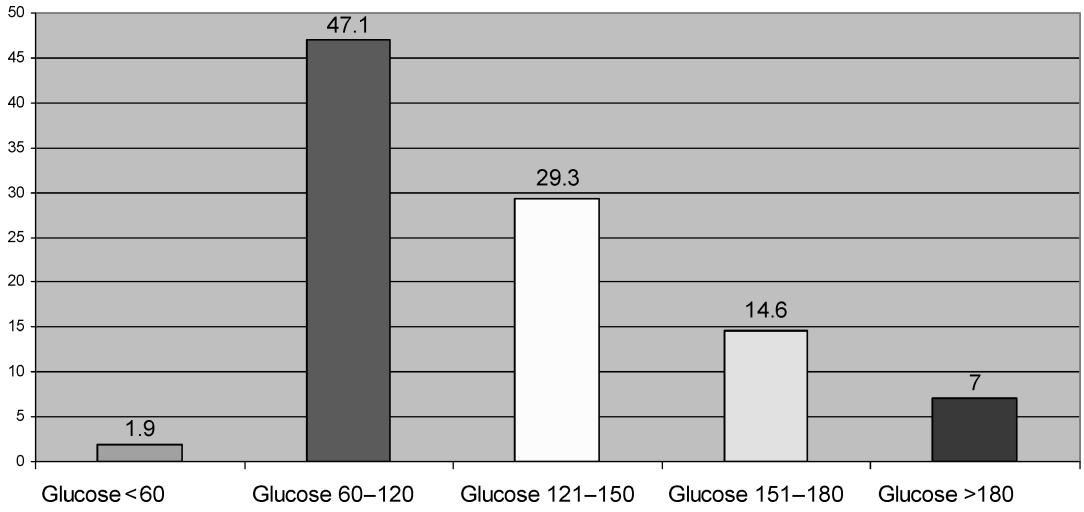


**Figure 6.** Memorial Hermann Southwest Hospital. Glucose level ranges collected daily at 8 AM from November 1 to 26, 2005. From VHA database (Available at: www.VHA.com/).

- Calls were made to the ordering physician by the pharmacist in an attempt to educate and achieve buy-in.
- The staff nurses were asked to encourage the physicians to use the new protocol instead of writing their own orders for insulin coverage.

## STILL NOT THERE

In March 2005, the team realized that the decline in blood glucose levels had been stalled. Over the previous 12 months (Fig 4), the average blood glucose level remained consistent at 150 mg/dL. The next course

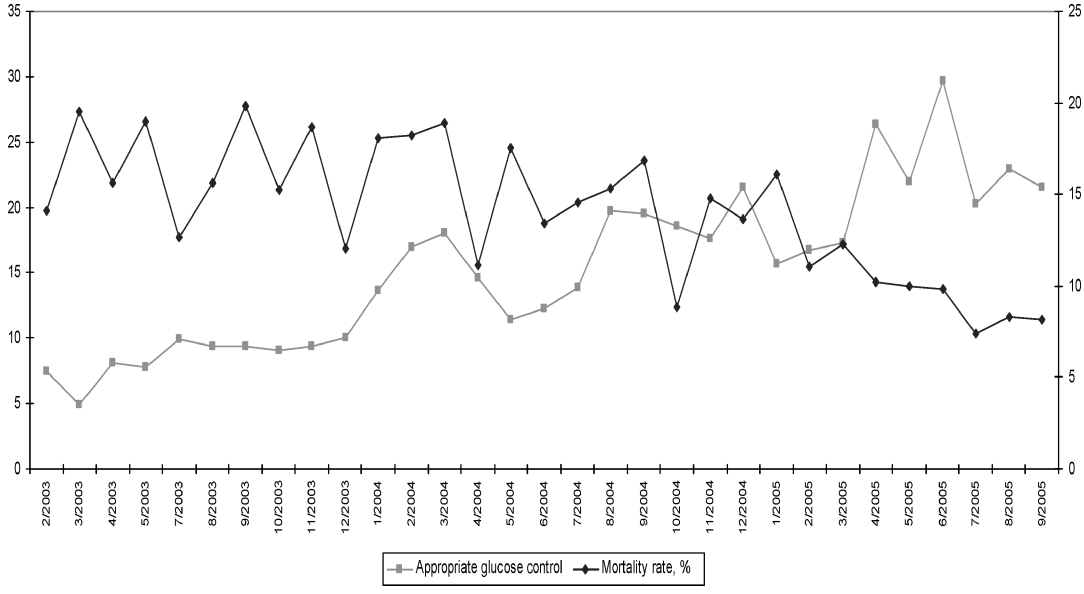


**Figure 7.** Memorial Hermann Southwest. Appropriate glucose control (80–110 mg/dL) vs mortality rate (%) from February to September 2005. From VHA database (Available at: www.VHA.com/).

of action was to analyze why this was so.

Each morning on daily rounds, the pharmacist reviewed each patient's blood glucose results from the previous 24 hours. All patients not in control were flagged for further analysis. Certain trends were identified:

- The subcutaneous dosing regimen was not sufficient coverage.
- The nurses were not checking the glucose levels frequently enough (ie, increasing blood glucose checks to hourly until target is achieved for 2 consecutive hours).
- Physicians' refusal to use the protocols.
- Blood glucose levels were not addressed on new admissions unless the patient had a history of diabetes or the admission glucose was greatly elevated.
- The patient had been started on TPN, enteral nutrition, or steroids the previous day.

## MAKING IT WORK

Pharmacy and nursing collaborated to reeducate the nursing staff on the latest research and goals for success. The nurses were encouraged to be proactive by requesting physicians to place their patients on an insulin regimen early. In addition to recommendations for insulin regimen adjustments, the rounding team began to suggest alternative measures that would affect the blood glucose levels throughout the evening and night hours. These measures included long-acting insulin therapy, changes to total parenteral nutrition (ie, additional insulin, decrease in calories), and enteral nutrition substitutions.

## THE PRESENT

We are well on our way to achieving our goal (Fig 5). In November 2005, 47.1% of blood sugar samples collected at 8:00 AM were within the target (60–120 mg/dL), 29.3% were between 121 and 150 mg/dL, and glucose levels greater than 180 mg/dL had dropped to 7% (Fig 6). Figure 7 shows an inverse correlation between mortality and appropriate glucose control (blood glucose level, 60–120 mg/dL). During this $2^1/_2$-year span, we made multiple improvements in the delivery of patient care. Therefore, we cannot claim a cause-and-effect link between glucose control and mortality in our study. However, recent literature on tight glucose control in the critical care patient has demonstrated a cause-and-effect relationship.

To further improve the quality of patient care, an automatic insulin protocol and corresponding guidelines have been designed to allow the critical care nurse to adjust the subcutaneous insulin regimen upward or downward, move to a drip, or return to subcutaneous coverage to meet the patient's metabolic needs. Implementation is due to begin in March 2006.

## SUMMARY

Tight glucose control will continue to be the standard of care for critically ill patients. The key to achieving and maintaining such a lofty goal is to keep it always in the forefront. Continual monitoring to test the reliability of the tools used and periodic reeducation of nurses and physicians on the latest research studies help keep the dream alive.

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