Case Study #1

- 70-year-old woman is hospitalized for worsening dyspnea and cough.
- She has had chronic obstructive pulmonary disease (COPD) since age 55.
- Physical exam reveals an anxious woman with blood pressure 130/70 mmHg, pulse 120, respiratory rate 24, and weight 180 lb. Lungs are clear to percussion, but wheezing is present bilaterally. No accessory muscles are being used. No cyanosis is present.
Case Study #1 (Cont.)

- Medications
  - Tiotropium bromide 2 inhalations every day (COPD)
  - Albuterol inhaler 2 inhalations as needed
  - Prednisone 20mg daily (COPD)
  - Ibandronate 1 monthly (Osteoporosis)
  - Amlodipine 5 mg 1 daily (HTN)
  - Lisinopril 10mg 1 daily (HTN)
  - Simvastatin 20 mg 1 daily (Cholesterol)
  - Fesoterodine 4mg 1 daily (Overactive Bladder)
Case Study #1 (Cont.)

- Laboratory Values
  - Na: 140/ K: 3.7/ Cl: 100/ CO2: 25
  - WBC: 12.5
  - BUN: 12/ Scr: 0.9
  - FBG: 110 mg/dL
  - A1c: 6.2%
  - LDL: 120 mg/dL; HDL: 40 mg/dL; TG: 140 mg/dL
The following slides will provide evidence or support for the possible right answer(s) and/or clinical assessment/calculations.
The following criteria are used to diagnose diabetes
a) fasting plasma glucose (FPG; after 8 or more hours of no caloric intake) of 126 mg/dL or greater, or
b) plasma glucose level of 200 mg/dL or greater, 2 hours after ingesting 75-g oral glucose load in the morning (after an overnight fast of at least 8 hours), or
c) symptoms of uncontrolled hyperglycemia (eg, polyuria, polydipsia, polyphagia) and a random (casual; non-fasting) plasma glucose of 200 mg/dL or greater, or
d) A1c of 6.5% and higher.

In the absence of unequivocal hyperglycemia or severe metabolic stress, the same test -glucose or A1C- should be repeated on a different day to confirm the diagnosis of diabetes (Grade D; BEL 4). Evaluation should be considered in the presence of risk factors for diabetes. New onset diabetes is not evident by this patient’s A1c or FPG levels.

Steroid-induced hyperglycemia is the most likely clinical assessment in this patient’s case. Glucocorticoids are well known to affect carbohydrate metabolism. They increase hepatic glucose production, inhibit glucose uptake into muscle, and have a complex effect on cell function. The decrease in glucose uptake with glucocorticoids seems to be the major early defect, and thus it is not surprising that for hospitalized patients who have well-controlled type 2 diabetes, postprandial hyperglycemia is the most significant finding. Hyperglycemia induced by glucocorticosteroids is primarily an exaggeration of postprandial hyperglycemia. Most patients will not have significantly different fasting blood glucose levels when they are receiving corticosteroids.

Stress-induced hyperglycemia (disease-related) is also possible Insulin resistance occurs due to counterregulatory hormone responses to stress (e.g., surgery) and/or illness and the use of corticosteroids, pressors, or other diabetogenic drugs.
Summary
The majority of patients receiving ≥2 days of glucocorticoid therapy at a dose equivalent of at least 40 mg per day of prednisone developed hyperglycemia. No glucose monitoring was performed in 24% of patients receiving high dose glucocorticoid therapy.

Study Description
Retrospective review of electronic medical records of patients admitted to the general medicine service at a university hospital during a 1-month period. Pharmacy charges were used to identify patients receiving high doses (>40 mg/day of prednisone or the equivalent) of corticosteroids for at least 2 days.

Findings
During the 1-month study period, 66 of 617 patients received high doses of corticosteroids, but only 50 of the 66 had glucose measurements. Hyperglycemia was documented in 32 of these 50 patients (64%), and multiple hyperglycemic episodes occurred in 26 (52%). A history of diabetes was documented in 12 of 26 patients who experienced multiple episodes, in comparison with 4 of 24 patients with ≤1 episode of hyperglycemia (P = 0.035). Among patients without a history of diabetes, 19 of 34 (56%) had hyperglycemia at least once. Patients with multiple episodes of hyperglycemia had more comorbid diseases, longer duration of corticosteroid therapy, and longer duration of hospital stay.

Conclusion
Hyperglycemia occurs in a majority of hospitalized patients receiving high doses of corticosteroids. In light of the poor outcomes associated with hyperglycemia, protocols targeting its detection and management should be available for patients who receive corticosteroid therapy.

Reference
**Summary**
Glucocorticoid-induced hyperglycemia is common in patients with and without diabetes.

**Study Description**
An electronic (MEDLINE) and a library review of the existing pertinent literature published from 1950 to March 2009.
Evidence level B, non-RCT

**Findings**
The odds ratio for new-onset diabetes mellitus in patients treated with glucocorticoids ranges from approximately 1.5 to 2.5. The best predictors of glucocorticoid-induced diabetes are family history of diabetes, increasing age, and glucocorticoid dose.

**Conclusion**
Glucocorticoid-induced hyperglycemia is an important clinical finding that, if recognized, can be effectively treated.

**Reference**
The following slides will provide evidence or support for the possible right answer(s) and/or clinical assessment/calculations.
Basal bolus insulin with emphasis on bolus insulin is the best intervention for a hospitalized patient receiving steroids.

Insulin therapy is the preferred method of glycemic control in the majority of hospitalized patients because of its rapid half-life, its powerful glucose-lowering ability, and the ease by which it can be titrated to adjust to the changing medical status of hospitalized patients. Scheduled subcutaneous insulin should consist of basal and nutritional or bolus insulin.

NPH insulin is considered intermediate in action and may be associated with a greater risk of hypoglycemia. It is a possible intervention, that will require appropriate monitoring.

Each of the major classes of non-insulin oral glucose-lowering drugs has significant limitations for inpatient use and thus, they are generally not recommended. These agents provide little flexibility or opportunity for titration in a setting where acute changes in patient status often demand such action.

Use of sliding scale insulin as the sole method of glucose control is discouraged because it is a reactive, not proactive, method of glucose control, relying on treatment after the fact of measured blood glucose levels.

Evidence Level C, Expert Opinion
Summary
Patients who develop hyperglycemia from glucocorticoids often experience disproportionate postprandial hyperglycemia. Basal bolus therapy with emphasis on the use of rapid-acting insulin analogs or regular human insulin to target postprandial hyperglycemia is one recommended approach to addressing hyperglycemia in a patient on high-dose steroids. If the duration of treatment with glucocorticoids is brief, patients may respond well to a mealtime dose of rapid- or short-acting insulin with a correction dose addition if glucose is elevated. If more prolonged therapy with glucocorticoids is anticipated, teaching an insulin-to-carbohydrate ratio may be advisable to reduce the risk of insulin-to-carbohydrate mismatch and resultant glucose fluctuations. Care must be taken to decrease insulin administration as glucocorticoids are tapered.

References
Evidence Level C, Expert Opinion

Evidence Level C, Consensus
**Summary**

NPH insulin may be used for patients receiving steroids because it is intermediate in action and has a peak which may correspond with the postprandial hyperglycemia induced by steroids. The use of prandial insulin in addition to NPH insulin in this scenario is not generally recommended.  

A suggested weight-based algorithm for insulin based on the known dose-response effects of GC on insulin sensitivity is shown in this table.  

The authors arrived at the doses on the basis of empiric observation during the past 5 years.  

The insulin doses are averages and may necessitate individual adjustment. In patients already receiving insulin, the doses listed are added to usual basal insulin.

**Reference**


Evidence Level C, Expert Opinion
Summary
Sliding Scale Insulin in patients with pneumonia is associated with higher glucose levels and poorer clinical outcomes.

Study Description
The medical charts of 391 patients > 45 years of age admitted with pneumonia from January 2003 to May 2004 who had a recorded glucose within 24h of admission were reviewed. Abstracted data included demographics, clinical characteristics, admission and daily glucose levels, medications, SISS use and clinical outcomes. The primary outcome was pre-defined as a composite of in-hospital mortality, cardiovascular complications, sepsis or ICU admission.

Evidence Level B, Non-RCT

Findings
Compared to patients not prescribed an SISS during admission, the 47 patients prescribed an SISS had a higher rate of the following outcomes: primary outcome (OR = 2.55; 95% CI 1.38–4.73); cardiovascular complications or death (OR = 1.86; 95% CI 0.99–3.49), sepsis or ICU admission (OR = 4.98; 95% CI 2.38–10.42). The relationship between sliding scale use and the primary outcome was statistically significant, even after controlling for age, sex, diabetes, steroids, CHF and COPD (P < 0.0001). Patients receiving a sliding scale had mean in-hospital glucose values of 213 mg/dL versus 130 mg/dL (P < 0.0001) in patients not receiving an insulin sliding scale.

Conclusion
Among patients admitted to a medical ward with pneumonia, an SISS is associated with higher glucose levels and poorer clinical outcomes.

Reference
Summary
Remarkably few published data have described the efficacy of the orally administered agents in GC-induced diabetes. This situation perhaps exists because each has inherent limitations in patients who require GCs. The benefits and risks of traditional oral agents is summarized in the table.

Reference
Steroid Therapy and Glycemic Control – General Guidelines

- The majority of patients (but not all) receiving high dose glucocorticoid therapy will experience elevations in blood glucose
- For patients without prior DM or hyperglycemia or those with diabetes controlled with oral agents:
  - Initiate glucose monitoring with low dose correction insulin scale administered prior to meals
- For patients previously treated with insulin
  - Increase total daily dose by 20–40% with start of high dose steroid therapy
  - Increase correctional insulin by one step (low to moderate dose)
- Adjust insulin as needed to maintain glycemic control

Evidence Level C, Expert opinion
Hyperglycemia and Glucocorticoid Therapy: Summary

- Institute glucose monitoring for at least 48 hours in all patients
- Prescribe insulin therapy as needed according to results of bedside BG monitoring
- During initiation and taper of steroid therapy, proactive adjustment of insulin therapy can help avoid uncontrolled hyperglycemia and hypoglycemia.

AACE Inpatient Resource Room, Evidence level C, expert opinion.
Case Study #1–Summary

- Patient is “new” to hyperglycemia, possibly pre-diabetes or related use
  - Educate / train patient (and family members) on SMBG meter
    - Patient should check BG fasting, pre-meals, and post-meals for 2 days to identify patterns (Expert opinion)
      - 7 times daily for 2 days
    - Once patterns identified, patient should self-monitor blood glucose 2-3 times daily, prn
  - Initiate rapid acting insulin (aspart, lispro, glulisine), 1-2 units 15 minutes prior to meal when BG is > 130 mg/dL (Expert Opinion)
  - Follow up with primary care physician within 1 week for repeat BG and medication review and adjustment
  - Follow up within 2 weeks with Certified Diabetes Educator for Diabetes Self-Management Education and insulin adjustment
  - Repeat A1c in 3 months, and quarterly to annually thereafter based on result (Expert opinion)
Case #2: 68-Year-Old Male
Admitted with AMI and CHF

- Medical History
  - Type 2 DM for 14 years
  - HTN
  - Hyperlipidemia
  - Gout

- Outpatient DM Meds
  - Metformin 1000 mg bid
  - Ramipril 10 mg qd + thiazide diuretic
  - Atorvastatin 40 mg qd + ezetimibe 10 mg qd

- Exam
  - Lungs w/ rales, 2+ lower extremity edema
  - Echo shows LVEF 25%

AMI, Acute Myocardial Infarction; CHF, congestive heart failure; DM, diabetes mellitus; L.E, lung edema; LVEF, left ventricular ejection fraction.
Case #2 (Cont.)

- Labs:
  - Admission glucose 256 mg/dL
    A1c 9.3%
  - Creatinine 2.5
  - LFTs- 2.5 X normal
- Admitted to CCU for emergent heart catheterization
- Blood glucose now 210 mg/dL

CCU, Cardiac care unit ; LFTs, liver function tests.
The observation that elevated glucose occurs frequently in the setting of acute myocardial infarction was made decades ago.

Since then more than 25 studies have documented that hyperglycemia is a powerful risk factor for increased mortality and in-hospital complications in patients with AMI.

Reference
Is this diabetes out of control? Is this stress hyperglycemia?
Ideally, his blood glucose level should be less than 180 mg/dL.
The following slides will provide insight as to the reason to reduce the level of
hyperglycemia of this patient.
Summary
Although some patients with AMI may experience resolution of hyperglycemia during hospitalization, in most cases, hyperglycemia persists throughout the hospital course.

Recent analysis of nearly 17,000 patients hospitalized with AMI showed that 41% of AMI patients have persistent hyperglycemia (mean hospitalization glucose > 140 mg/dL) and about 14% have persistent severe hyperglycemia (mean hospitalization glucose > 200 mg/dL).

Reference
Summary
Hyperglycemia in patients with acute MI is associated with a linear increase in mortality rate. Plot his glucose level of 210 mg/dL and ascertain his chances of 30-day mortality. Note that one-year mortality is more striking.

In a cohort of 141,680 elderly patients, a clear, linear relationship was demonstrated between admission glucose levels and both 30-day and 1-year mortality.

Reference
Summary
Data from the same study clearly demonstrated a powerful relationship between average glucose during hospitalization and in-hospital mortality.

Fewer hyperglycemic patients without known diabetes received insulin during hospitalization than did those with known diabetes and similar glucose levels (eg, glucose > 240 mg/dL, 22% versus 73%; \( P < 0.001 \)).

Reference
Study Description
Analysis of 1469 AMI patients with baseline and 24 h glucose data from the CARDINAL trial database. Baseline glucose and the 24 h change in glucose (24 h glucose level subtracted from baseline glucose) were included in multivariable models for 30- and 180-day mortality.

Conclusions:
Failure of glucose levels to decrease in the first 24 h after AMI predicted higher mortality in these nondiabetic patients.

Reference
Summary
Glucose normalization after admission is associated with better survival in hyperglycemic patients hospitalized with acute myocardial infarction whether or not they receive insulin therapy.

Study Description
7820 hyperglycemic (admission glucose level ≥ 140 mg/dL) patients with acute myocardial infarction hospitalized in 40 US hospitals. Patients were stratified according to their mean glucose levels after admission and were divided into those who did and did not receive insulin therapy. Multivariable logistic regression models were developed to examine whether lower glucose levels after admission are independently associated with better survival.

Findings
After multivariable adjustment, lower mean postadmission glucose levels were associated with better survival (for mean postadmission glucose levels of 110 to < 140, 140 to < 170, 170 to < 200, and ≥ 200 mg/dL. The odds ratios [95% confidence intervals] were 2.1 [1.3-3.5], 5.3 [3.0-8.6], 6.9 [4.1-11.4], and 13.0 [8.0-21.3], respectively, vs < 110 mg/dL). Similar results were seen in patients who did and did not receive insulin therapy.

Conclusions
Glucose normalization after admission is associated with better survival in hyperglycemic patients hospitalized with acute myocardial infarction whether or not they receive insulin therapy.

Reference
Summary
Physiologic studies show that elevated glucose is associated with microvascular dysfunction, vascular inflammation, prothrombotic state, endothelial dysfunction, and generation of reactive oxygen species.

In addition, hyperglycemia has been linked with higher free fatty acid concentrations (which could have a proarrhythmic effect) and impaired myocardial glucose use, increasing the consumption of oxygen and potentially worsening ischemia.

All of these mechanisms may increase myocardial injury in a setting of AMI and may explain the relationship between poor glucose control and adverse outcomes in this patient population.

Reference
Summary
Few observational studies have evaluated the impact of in-hospital insulin therapy on mortality in hyperglycemic AMI patients.

Insulin remains the most effective method of glucose lowering in the inpatient setting.

Small, mechanistic studies suggested that insulin may have anti-inflammatory, profibrinolytic, and antiapoptotic properties and can inhibit the generation of reactive oxygen species and improve myocardial blood flow.

Reference
The level of evidence for addressing hyperglycemia in patients with acute MI is based on non-randomized trials suggesting adverse outcomes with increasing glucose levels.

The choice of treatment regimen is predicated on the location of this patient—in the hospital setting, with possibly changing glucose levels.

The following slides will provide more insight as to the correct choice of therapy.
Each of the major classes of non-insulin oral glucose-lowering drugs has significant limitations for inpatient use and thus, they are generally not recommended. These agents provide little flexibility or opportunity for titration in a setting where acute changes in patient status often demand such action.

Therefore the correct answer is insulin, which is the preferred method of glucose control in the hospital setting.

Level of Evidence C, expert opinion
Insulin infusion is the most effective method for controlling hyperglycemia in critically ill patients.

IV insulin decreases blood glucose levels in a reasonable time period (6 to 10 hours), permits rapid titration of dose for anticipated (for example, initiation or discontinuation of vasopressors) or unanticipated (for example, acute deteriorations in clinical status) changes in a patient’s clinical status and minimizes glycemic excursions more effectively than does subcutaneous (SC) insulin.

Level of Evidence C, consensus

References

Summary
There are limited outcomes data, and none using currently recommended treatment goals, in patients with AMI.

In the original DIGAMI study, patients with acute MI received IV insulin therapy for 24 hours, followed by multiple daily injections for 3 months or longer with a target glucose of 126–180 mg/dL. The treatment group had a 29% reduction in mortality at one year and 28% at 3.4 years compared to control.

The HI-5 study used a similar design to DIGAMI (target was 72–180 mg/dL in the intensive arm), but failed to achieve a statistically significant difference in glucose values between intensive and conventional glucose groups (149 mg/dL vs 162 mg/dL post randomization, \( P \) = not significant).

Nevertheless, while mortality rates were not significantly different between the groups, the prespecified end points of reinfarction and heart failure were markedly lower in patients who received intensive glucose control.

The DIGAMI-2 study also failed to achieve a significant glucose contrast between the groups and was similarly mortality neutral.

References


Summary
Current consensus is that treatment with insulin should be considered in AMI patients with severe hyperglycemia (>180 mg/dL)

National patterns of glucose control and insulin use in patients with MI show:
- that among patients with severe, sustained hyperglycemia (mean hospitalization glucose ≥ 200 mg/dL), nearly 40% of patients did not receive any insulin therapy
- there was substantial variability in insulin treatment rates across the 40 participating medical centers

References


Achieving Safe and Effective Glucose Control in the Cardiac Care Unit

- Use of Evidence-Based Protocols
  - Preferably those that take into account not only the current glucose value, but the direction and magnitude of change over times, as well as patients’ insulin sensitivity
  - Several published can be adapted
    - Visit American Association of Clinical Endocrinologists (AACE) resource room on inpatient hyperglycemia
      - http://resources.aace.com

Evidence level C. expert opinion.
Case Study #2: Management

- An IV insulin infusion (1 unit/ml of regular insulin) titrated hourly initially to achieve a glucose level < 180 mg/dL.
  - After stabilization of blood glucose levels, monitoring is decreased to q 4 hours.
  - By 12 hours, a blood glucose level of 160 mg/dL is achieved.
Case Study #2: Management

- 3 days later
  - Acute CHF has resolved; LVEF is now 45%
  - Creatinine is 1.2 mg/dL; LFT now 1.5X normal
- Patient is being considered for discharge
- Discharge medications will include
  - Plavix
  - ASA
  - A beta-blocker
  - A statin drug
  - An ACE inhibitor
  - Loop Diuretic

ACE, angiotensin-converting enzyme; ASA, acetylsalicylic acid.
The following slides will provide insight into a recommended treatment approach for this patient when they are discharged. Bear in mind that the patient has diabetes out of control upon admission with the use of metformin therapy.
The correct answer is to restart metformin and to add once-daily basal insulin analog. The patient was not at goal on metformin alone; therefore combination therapy is indicated. Because the A1C needs to be lowered by more than 1 percentage point, it is unlikely that addition of another oral agent will bring this patient to goal.

If patients have a previous diagnosis of diabetes and are admitted to the hospital, usually for a reason other than diabetes; hospitalization is an opportunity to evaluate long-term diabetes control adjust therapy as needed.

Reference
McDonnell M, Donahue M. Transitioning Patients Along the Continuum of Care—Intravenous to Subcutaneous Insulin, Inpatient to Outpatient Settings: Practical Considerations. ACP Hospitalist. 2009; 24-30. Evidence Level C, review
Certainly it is time to move to combination therapy for this patient who has had T2DM for 14 years and has A1C levels well above goal.

Data from the UKPDS show that after 9 years of treatment, only a quarter patients were able to maintain good glycemic control with a single agent. This is because T2DM is a progressive disease, characterized by increasing beta-cell dysfunction, which limits the efficacy of monotherapy. After 9 years of monotherapy with diet, insulin, or sulfonylurea, 8%, 42%, and 24% of patients, respectively, maintained an A1C <7%.

The evidence level for moving to combination therapy is “A”, data from RCTs

Reference
Summary
Medication “durability”—the ability to maintain glycemic control with a given agent over time—may be useful in therapeutic decision making. Different classes of drugs appear to have different degrees of durability. A Diabetes Outcome and Progression Trial (ADOPT) evaluated rosiglitazone, metformin, or glyburide as initial treatment for patients with recently diagnosed T2DM revealed that the lowest 5-year failure rate of monotherapy was with the thiazolidinedione (TZD) rosiglitazone (15%); an intermediate failure rate was reported for metformin (21%); and the highest failure rate was associated with the sulfonylurea glyburide (34%).

For the patient in our case study, a TZD is not recommended given the history of CHF.

Reference
Case Study #2: Management

- The patient is restarted on metformin (Evidence Level A, RCT)
- Long-acting insulin analog 10 units at bedtime is started, which will be titrated every 3 days to achieve fasting plasma glucose levels < 110 mg/dL (Evidence Level A, RCT)
- The sulfonylurea is not restarted because it may increase the risk of hypoglycemia if used with insulin and may no longer be effective if beta cell impairment due to disease duration is a factor (Evidence level A, RCT)
- A TZD is not recommended based on prior history of CHF (Evidence level A, RCT)
Case Study #2: Management

- The patient and his family members are educated by a pharmacist or a nurse prior to discharge to ensure they know how to administer insulin, test blood glucose (Evidence Level C, Expert Opinion)
- Education about signs/symptoms, prevention and treatment of hypoglycemia is provided (Evidence Level C, Expert Opinion)
- A follow-up appointment with the patient’s primary care physician is scheduled to assess patient response and to make the first dose adjustment in person (Evidence Level C, Expert Opinion)
Numerous studies have definitively established that hyperglycemia is highly prevalent and associated with an increased risk of death and in-hospital complications and that resolution of on-arrival hyperglycemia is associated with improved survival in patients hospitalized with AMI. However, due to the lack of appropriately designed randomized trials, the definitive answer in regards to glucose management in patients with AMI, including treatment thresholds and glucose targets, is lacking.

Reference
Case Study #3

- An obese 49 year-old man is admitted with acute myocardial infarction
- He has no history of diabetes, but the admission BG is 186 mg/dL
- He is brought to the cath lab, where PCI of an LAD occlusion is performed
  - Post-PCI, his BG is 215 mg/dL, but over the next 2 days, a fasting glucose falls to 122 mg/dL
  - HbA1c is 6.7%

BG, blood glucose; LAD, left anterior descending; PCI, percutaneous coronary intervention.
This patient has diabetes, based on the ADA criteria of A1c greater than or equal to 6.5 percent.
The following slides will provide support for treatment recommendations based on this patient’s clinical status.
Summary

Evidence level C, expert opinion

There are many possible reasons for patients to have hyperglycemia while hospitalized, including poorly controlled diabetes, undiagnosed diabetes, and stress/temporary hyperglycemia.

Potential examples of conditions or treatments associated with stress/temporary hyperglycemia include surgery, acute myocardial infarction (MI), trauma, and steroids.

Hyperglycemia may occur in patients with previously diagnosed diabetes due to, for example, uncontrolled diabetes and infection.

Hyperglycemia may occur in patients who have previously undiagnosed diabetes, such as gestational diabetes.

Reference
If patients have a previous diagnosis of diabetes and are admitted to the hospital, usually for a reason other than diabetes; hospitalization is an opportunity to evaluate long-term diabetes control and initiate new therapy. This may also be an opportunity to assess for microvascular or macrovascular complications of the disease.

Reference
Recommended Treatment Strategies on Discharge

Previously diagnosed DM, on orals & suboptimal control:

- **A1C 7–8%**: Consider increasing dose of home oral agents or adding additional agent, potentially including basal insulin
- **A1C 8–9%**: Add an additional agent, probably including basal insulin.
- **If A1C > 9%**: Usually discharge on an insulin regimen...
  - QD basal insulin
  - BID premixed
  - Basal-bolus

BID, two times a day; QD, once a day.


Reference
Summary
Almost a third of patients who have diabetes are unaware of their diagnosis. Hospitalization provides an opportunity to make the diagnosis and initiate long-term care.

The discharge recommendations for those with newly recognized glucose abnormalities must emphasize a plan to evaluate the cause of the hyperglycemia.

References

Summary
Patients with newly diagnosed diabetes should receive a plan of care and outpatient follow-up. Depending on the degree of hyperglycemia, initiation of therapy in the hospital may be warranted.

Evidence level C, expert opinion

Reference
Summary
Patients may have transient hyperglycemia (e.g., hyperglycemia in response to the stress of illness or due to treatments such as high-dose corticosteroids).

Hyperglycemia usually resolves by the time of discharge, but these patients may need long-term follow-up because many have some degree of glucose intolerance. The discharge recommendations for those with newly recognized glucose abnormalities must emphasize a plan to evaluate the cause of the hyperglycemia. Because hyperglycemia may be transient and situational, diabetes cannot be diagnosed in the hospital by using commonly accepted criteria. Therefore, obtaining a reliable hemoglobin A1c (HbA1c) level as part of the evaluation of hyperglycemic patients in the hospital is increasingly favored by some clinicians. The HbA1c is an accurate indicator of glycemic control for 2 to 3 months.

Reference
Summary
In patients with modest elevation of A1c, but without overt diabetes, lifestyle intervention is the cornerstone of therapy. Some patients may be candidates for metformin therapy although no agent is approved for the treatment of prediabetes.

Evidence level C, expert opinion

Reference
Summary
Patients who are hospitalized for other reasons may not receive or comprehend fully any information provided about glycemic status and current or future risk of diabetes. Most importantly, almost a third of patients did not have any arrangements made for follow-up care.

Reference
Summary
A smooth inpatient-to-outpatient transition is critical. Appropriate discharge planning with identification of subsequent glycemic management plans and follow-up should be explicit. Goal-directed glycemic management in the hospital will serve as a model for the patient’s self-directed care after discharge. However, there may be many challenges to effective discharge planning.

Reference:
Evidence level C, Expert opinion
Because hospitalizations for acute illness usually are shorter than 5 days, discharge planning for the patient with diabetes in the hospital ideally begins on day 1 of admission.

Many factors must be considered in designing the outpatient management plan (including evaluation of the patient’s skill set); thus, starting the transition process early in admission is recommended.

An HbA1c value can be obtained early in a hospital stay to help direct discharge planning.

Evidence level C, expert opinion

Reference
The following criteria may be used to diagnose diabetes:

a) fasting plasma glucose (after 8 or more hours of no caloric intake) of 126 mg/dL or greater,

b) plasma glucose level of 200 mg/dL or greater, 2 hours after ingesting 75-g oral glucose load in the morning (after an overnight fast of at least 8 hours) or

c) symptoms of uncontrolled hyperglycemia (eg, polyuria, polydipsia, polyphagia) and a random (casual; non-fasting) plasma glucose of 200 mg/dL or greater

In the absence of unequivocal hyperglycemia or severe metabolic stress, the test should be repeated on a different day to confirm the diagnosis of diabetes.

Evaluation should be considered in the presence of risk factors for diabetes. A1c of 6.5% and above is an alternate way to diagnose diabetes, however confirmatory glucose tests are recommended.

References


Transitioning the Patient to Discharge
Case Study #3: Summary

- Hyperglycemic inpatients generally fall into 3 categories (Evidence Level A, RCT):
  - Known DM
  - Previously unrecognized DM
  - “Stress hyperglycemia”
- Discharge planning and follow-up will differ in each (Evidence Level C, Expert opinion)
- Quality discharge planning includes patient education, medication reconciliation, precise prescription instructions, & documented plans for follow-up care (Evidence Level C, Expert opinion)
Case Study #4

A 48-year-old woman with a 5-year history of type 2 DM is ready to eat 36 hours after coronary artery bypass graft surgery

- Between 1 AM and 7 AM, she was receiving an average of 2 units of intravenous regular insulin per hour, with a glucose level of 130–150 mg/dL.

- She was given a small amount of juice at 7 AM, and her glucose level increased to 195 mg/dL, prompting an increase in the infusion rate to 3 U/h.
Summary
The ultimate insulin regimen should address the 3 components of insulin requirement:
• basal (what is required in the fasting state to maintain normal metabolism)
• nutritional (what is required for peripheral glucose disposal), and
• correctional (what is required for unexpected glucose elevations)

Reference
Physiologic Components of Insulin Therapy

- **Basal insulin**: detemir (Levemir®), glargine (Lantus®), NPH (Humulin® N, Novolin® N)
  - The amount of insulin necessary to regulate glucose levels between meals and overnight
- **Nutritional insulin**: aspart (NovoLOG®), glulisine (Apidra®), lispro (Humalog®), regular (Humulin® R, Novolin® R)
  - The amount of insulin required to cover meals, IV dextrose, enteral nutrition, TPN or other nutritional supplements
- **Correctional insulin**: (Supplemental insulin)
  - Refers to supplemental doses of rapid or short acting insulin given to correct elevations in blood glucose that occur despite use of basal and nutritional insulin
  - Usually administered before meals together with prandial insulin

IV, intravenous; TPN, total parenteral nutrition
Studies in inpatient critical care areas have determined successful dose-finding strategies by extrapolating 24-hour doses from insulin infusion rates over the past 6 hours.

The following slides will walk you through the calculations.
Calculating the Basal Dose

- For patients who are not receiving significant calories, the infusion rate represents the basal insulin requirement.
- Using the fasting overnight rate of 2 U/h, the total basal insulin requirement is calculated as 2 U/h multiplied by 24 = 48 units.
- Generally, start with 80% of this value as basal dose to be conservative.
- 80% of 48 units is 38 units.


Calculating the subcutaneous insulin transition dose

The answer is 38 units.

Evidence level C, expert opinion

In a study conducted in the surgical intensive care unit, the 24-hour insulin requirement was calculated by taking the total amount of insulin infused within the past 6 hours and multiplying by 4. Of note, the insulin was infused while the patient was not receiving significant calories, so the infusion rate represented the “fasting” insulin requirement. In this study, a safe and effective basal insulin dose for the subsequent 24 hours was calculated as 80% of this estimated requirement.

Reference


Evidence level B, non-RCT
The following slides will provide a pharmacokinetic rationale for when basal insulin should be started.
The 34 Units is Given as Detemir or Glargine Insulin 2 Hours Before Discontinuation of the Insulin Infusion

- To prevent the recurrence of hyperglycemia, the insulin infusion and the subcutaneous insulin must overlap because the duration of insulin effect when given intravenously is less than 1 hour.
- Because of the time required for subcutaneous basal insulin to reach adequate levels in the bloodstream, an insulin infusion should be discontinued 2 hours after a basal dose is given.

Case Study #4 (Cont.)

- Because the patient is expected to eat at the next mealtime, nutritional insulin is ordered (Evidence-level B, non-RCT)
- Rapid-acting insulin analog is preferred to regular human insulin (Evidence Level A, RCT)
  - Aspart, glulisine, or lispro to be given at each meal, within 15 minutes before or after the first bite of food
The following slides will continue the calculations based on this patient's IV dose of insulin.
Case Study #4: Prandial Insulin Doses

- The rapid-acting analog daily requirement is expected to be as high as 38 U per day, split into 3 doses of 10 to 12 U per meal
- However, until the patient is eating well (for example, > 50% of meal) the rapid-acting insulin dose is started at 6 U with each meal

McDonnell M, Bonehuc M. ACP Hospitalist. 2002;24:30.
Evidence level C, expert opinion.
Case Study #4: Modifications to Therapy

- Nursing is instructed to hold the rapid-acting insulin if the meal is missed or the glucose level is low (Evidence Level B, non-RCT)
- Correctional insulin is ordered to be added if the glucose level exceeds the target glucose range (Evidence Level B, non-RCT)
While hypoglycemia has been variably defined in the literature, the inpatient hyperglycemia consensus statement has some specific recommendations to ensure the safe use of insulin in the hospital setting.

For Patient Safety, Hypoglycemia Should be Defined as:

A. < 50 mg/dL
B. < 70 mg/dL
C. < 90 mg/dL
D. <140 mg/dL
Summary
There should be a clear definition of hypoglycemia. Severe hypoglycemia in hospitalized patients has been defined by many clinicians as a BG of < 40 mg/dL, although this value is lower than the approximate 50–70 mg/dL level at which cognitive impairment begins in normal persons. Hypoglycemia should be defined as any BG value of < 70 mg/dL.

Hypoglycemia should be treated promptly.

References


Hypoglycemic events can be minimized with improvement in, standardization of, and careful implementation of protocols.
Summary
BG monitoring will dictate what changes need to be made. The slide shows that if blood glucose levels are in the target range, then no dose adjustment is required; however adjustments should be made for levels above or below target ranges to maintain recommended blood glucose levels.
Case Study #4: Summary

- There are 2 general principles behind a safe and effective transition from intravenous to subcutaneous insulin:
  1. The 24-hour insulin requirement is extrapolated from an appropriately selected hourly insulin rate
  2. The subcutaneous insulin program is designed to fit the patient's nutrition program (as well as any other complicating factors such as steroid use, etc)

Evidence level C, expert opinion.