A Night On-Call Managing Hyperglycemia in the Hospital

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Transitions

QUESTION 1.

A 32 year-old African American woman is admitted to the hospital with a diagnosis of pyelonephritis. She had a baby two years ago and was told that she had high blood sugars at that time, but did not see a doctor after the baby was born.

Her blood sugar on admission is 260 mg/dL. A urine pregnancy test is negative.

The patient likely has which of the following types of diabetes mellitus?

A. Type 1 DM
B. Type 2 DM
C. Maturity onset diabetes of the young (MODY)
D. Gestational diabetes mellitus

Know What Type of Diabetes Mellitus Your Patient Has…

Clinical features distinguishing type 1 diabetes, type 2 diabetes, and maturity onset diabetes of the young

Clinical features	Type 1 diabetes mellitus	Type 2 diabetes mellitus	MODY
Age of diagnosis (years)	Majority <25, but may occur at any age	Typically >25 but incidence is increasing in adolescents, paralleling increasing rates of obesity in children and adolescents*	<25
Weight	Usually thin, but with obesity epidemic overweight and obesity at diagnosis becoming more common	>90% at least overweight	Similar to general population
Autoantibodies	Present	Absent	Absent
Insulin dependent	Yes	No	No
Insulin sensitivity	Normal when controlled	Decreased	Normal (may be decreased if obese)
Family history of diabetes	Infrequent (5 to 10%)	Frequent (75 to 90%)	Multigenerational, ie, >2 generations
Risk of diabetic ketoacidosis	High	Low	Low

MODY: maturity onset diabetes of the young.
* In North America, type 2 diabetes predominates in Hispanic, African-American, Native American, Canadian First Nation, Pacific Islander, and Asian-American youth.

Why is it important to know what type of diabetes your patient has?

QUESTION 2.

The patient in question 1 actually presented to the hospital with DKA and is admitted to the ICU. She is found to have pyelonephritis. She is started on an insulin drip and her anion gap closes. She is sent to the medical floor under your care.

You are concerned that the patient may have type 1 DM due to her presentation of DKA, but find it atypical based on her age and history of gestational diabetes.

You order antibody testing to glutamic acid decarboxylase (GAD 65) and tyrosine phosphatase IA-2 and these return as negative.

Which of the following types of diabetes does this patient most likely have?

A. Acquired Type 1 DM Mellitus
B. Idiopathic Type 1 DM Mellitus
C. Late Autoimmune Diabetes in Adults (LADA)
D. None of the above

CLASSIFICATION OF DM

- **TYPE 1**
  - Immune-mediated (1A)
    - Anti-GAD65 and Anti-tyrosine phosphatase 1A-2
    - Late Autoimmune Diabetes in Adults
  - Idiopathic (1B) (Seronegative)
    - Episodic DKA
    - Strong family history of type 2
    - Asian and African American
  - Acquired
    - Pancreatic destruction

- **TYPE 2**
- Insulin Resistance
- MODY (genetic defect in beta-cell function)
- Endocrinopathies
  - Cushing syndrome
  - Acromegaly
  - Thyrotoxicosis
- Drug related
  - Steroids, thiazides, tacrolimus, cyclosporine, HIV protease inhibitors
- Genetic Syndromes
  - Down syndrome, Prader-Willi, Turner, Kleinfelter

QUESTION 3.

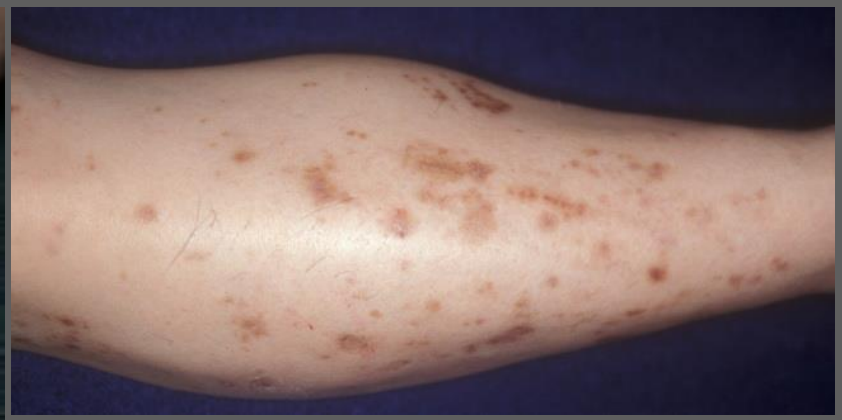
Your second admission for the night is a 35 year-old woman who presents to the hospital for cellulitis of her right lower leg that failed outpatient oral antibiotic therapy. She is found to be hyperglycemic on labs drawn in the ED with a blood sugar of 300 mg/dL. She denies a history of diabetes. You notice a rash around her neck and axilla.

Which of the following are the correct terms for the skin findings seen in these pictures?

A. Acanthosis nigricans, diabetic dermopathy
B. Acanthosis nigricans, acrochordrons
C. Acanthosis nigricans, necrobiosis diabeticorum
D. Acanthosis nigricans, scleredema diabeticorum

SKIN FINDINGS IN DM

Necrobiosis Lipoidica Diabeticorum (NLD)



Diabetic dermopathy

Scleredema Diabeticorum

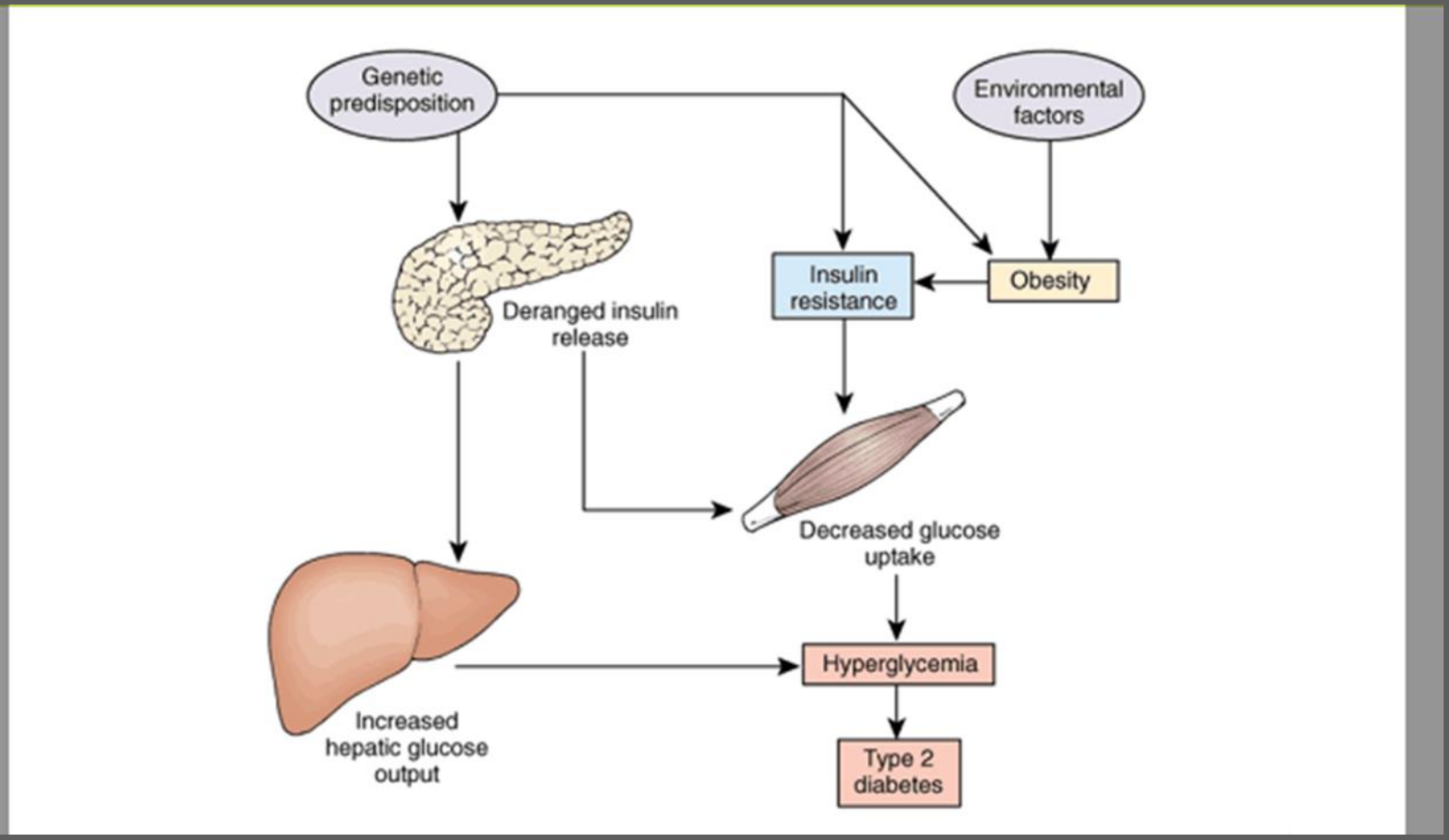
QUESTION 4.

You determine that this 35 year old woman that you are admitting with cellulitis likely has type 2 DM based on her physical exam findings of obesity, acanthosis nigricans, and acrochordons (skin tags).

Which of the following is NOT an explanation for the pathophysiology of type 2 diabetes mellitus?

A. Insulin resistance at the level of the muscle
B. Insulin resistance at the level of the liver
C. Inadequate insulin release from the pancreas
D. All of the above are pathophysiologic explanations of type 2 diabetes mellitus

Understand the Pathophysiology of Diabetes Mellitus Type 2



How do the medications used for type 2 diabetes treat the various pathophysiologic mechanisms of the disease?

QUESTION 5.

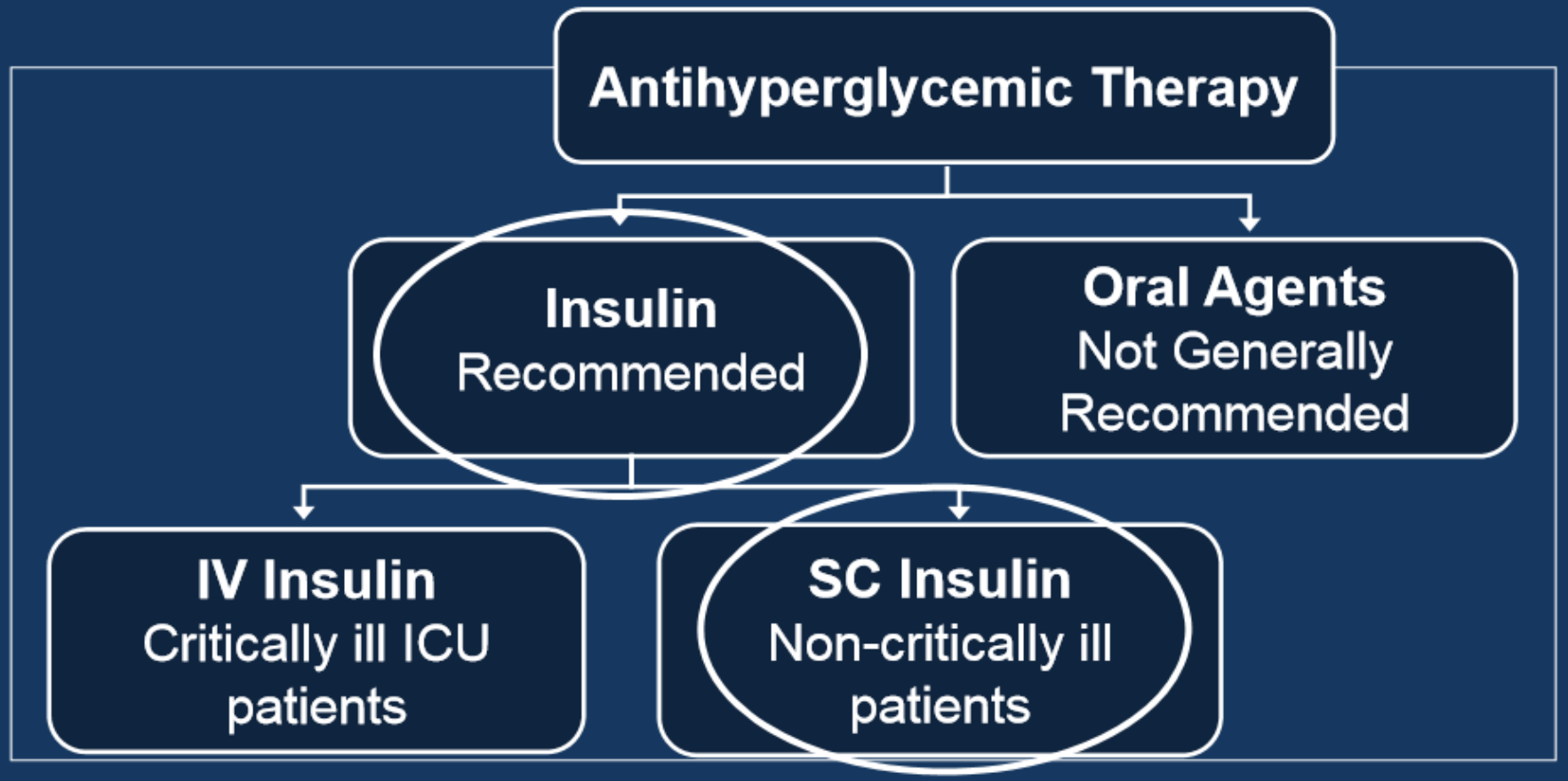
Your patient is admitted to the general medical floor and started on IV antibiotics for her cellulitis.

She is febrile to 101 F and is complaining of being nauseated.

Which of the following is the most appropriate medical therapy to start on this patient in the hospital setting at this time?

A. IV insulin drip
B. Subcutaneous basal, bolus, and correctional insulin
C. Subcutaneous correctional (sliding scale) insulin
D. Oral metformin

Recommendations for Managing Inpatient Hyperglycemia



Clement S, et al. *Diabetes Care.* 2004; Moghissi ES, et al. *Endocr Pract.* 2009.

Physiologic Insulin Replacement: Basal – Bolus Regimens

Aspart
Lispro
Glulisine
Regular

50% Bolus Insulin

50% Basal Insulin

Total Daily Dose (TDD)

Glargine
Detemir
NPH

Insulin Types and Pharmacology

Insulin type	Approximate onset of action	Peak effect	Approximate duration of action*
Lispro, aspart, faster aspart, glulisine	3 to 15 minutes	45 to 75 minutes	2 to 4 hours
Regular	30 minutes	2 to 4 hours	5 to 8 hours
NPH	2 hours	4 to 12 hours	8 to 18 hours, with usual duration of action around 12 hours
Insulin glargine	2 hours	No peak	20 to >24 hours
Insulin detemir	2 hours	3 to 9 hours	6 to 24 hours¶
NPL	2 hours	6 hours	15 hours
Insulin degludec	2 hours	No peak	>40 hours

NPH: neutral protamine hagedorn; NPL: neutral protamine lispro.

* Glucose-lowering action may vary considerably in different individuals or within the same individual.

¶ Duration of action is dose dependent. At higher doses (≥0.8 units/kg), mean duration of action is longer and less variable (22 to 23 hours).

QUESTION 6.

You have decided on using basal/bolus and correctional insulin for your hospitalized patient.

Which of the following values will help you determine what the initial total daily insulin dose (TDD) should be initially prescribed to your patient who ***was not on insulin*** prior to the hospitalization?

A. Hemoglobin A1c%
B. Creatinine
C. Body Mass Index (BMI)
D. A and C
E. All of the above

Step 1: Calculate Starting total daily dose (TDD):

1. IV requirements
2. Home dose
3. Weight based 0.2-0.5 units/kg/day
    1. Most recent guides say 0.2-0.5
    2. Rabbit trials 0.3-0.5
        - 0.3 ESRD or elderly (>70 y.o.)
        - 0.4 units/kg/day if admit BG 140-200
        - 0.5 units/kg/day if admit BG >200

Step 2: Divide into Scheduled Basal vs. Nutritional Insulin

- 40-50% should generally be basal
- Remaining 50-60% divided evenly and given to cover nutritional intake

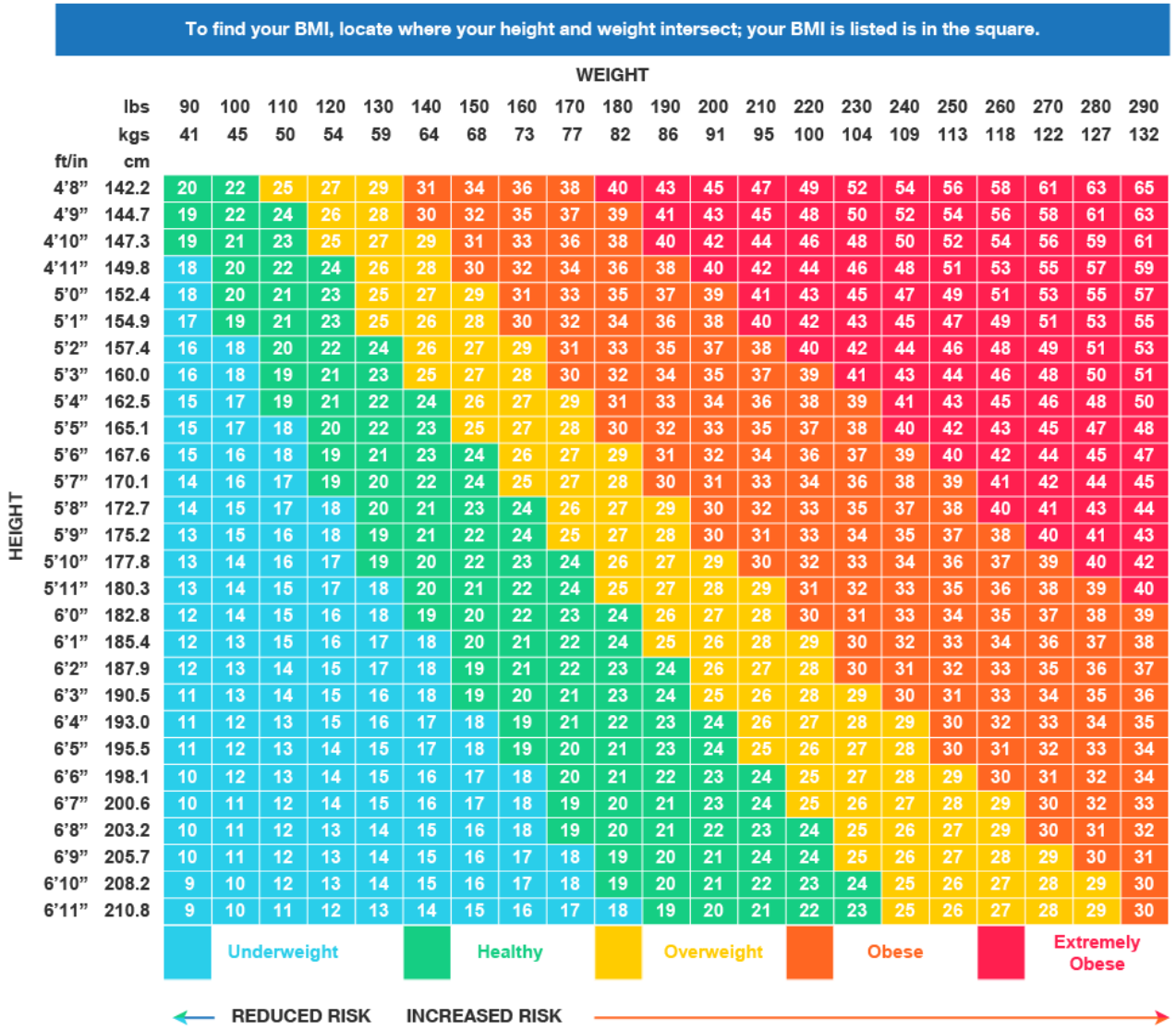
QUESTION 7.

You start your patient on a total daily dose of 0.5 units/kg per because her renal function is normal and her admission glucose was > 200. Her BMI is 30 and she is 61 inches tall (5' 1").

You divide the total daily dose (TDD) into basal (glargine) and bolus (lispro) insulin with correctional insulin sliding scale.

This is the insulin order based on your calculations:

A. 18 units glargine insulin Q HS and 6 units of lispro insulin Q AC plus correctional sliding scale
B. 36 units glargine insulin Q HS and 12 units of lispro insulin Q AC plus correctional insulin sliding scale
C. 45 units glargine insulin Q HS and 15 units of lispro insulin Q AC plus correctional sliding scale
D. 60 units glargine insulin q HS and 20 units of lispro insulin Q AC plus correctional sliding scale



ft/in	cm	lbs	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
		kgs	41	45	50	54	59	64	68	73	77	82	86	91	95	100	104	109	113	118	122	127	132
4'8"	142.2		20	22	25	27	29	31	34	36	38	40	43	45	47	49	52	54	56	58	61	63	65
4'9"	144.7		19	22	24	26	28	30	32	35	37	39	41	43	45	48	50	52	54	56	58	61	63
4'10"	147.3		19	21	23	25	27	29	31	33	36	38	40	42	44	46	48	50	52	54	56	59	61
4'11"	149.8		18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	51	53	55	57	59
5'0"	152.4		18	20	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57
5'1"	154.9		17	19	21	23	25	26	28	30	32	34	36	38	40	42	43	45	47	49	51	53	55
5'2"	157.4		16	18	20	22	24	26	27	29	31	33	35	37	38	40	42	44	46	48	49	51	53
5'3"	160.0		16	18	19	21	23	25	27	28	30	32	34	35	37	39	41	43	44	46	48	50	51
5'4"	162.5		15	17	19	21	22	24	26	27	29	31	33	34	36	38	39	41	43	45	46	48	50
5'5"	165.1		15	17	18	20	22	23	25	27	28	30	32	33	35	37	38	40	42	43	45	47	48
5'6"	167.6		15	16	18	19	21	23	24	26	27	29	31	32	34	36	37	39	40	42	44	45	47
5'7"	170.1		14	16	17	19	20	22	24	25	27	28	30	31	33	34	36	38	39	41	42	44	45
5'8"	172.7		14	15	17	18	20	21	23	24	26	27	29	30	32	33	35	37	38	40	41	43	44
5'9"	175.2		13	15	16	18	19	21	22	24	25	27	28	30	31	33	34	35	37	38	40	41	43
5'10"	177.8		13	14	16	17	19	20	22	23	24	26	27	29	30	32	33	34	36	37	39	40	42
5'11"	180.3		13	14	15	17	18	20	21	22	24	25	27	28	29	31	32	33	35	36	38	39	40
6'0"	182.8		12	14	15	16	18	19	20	22	23	24	26	27	28	30	31	33	34	35	37	38	39
6'1"	185.4		12	13	15	16	17	18	20	21	22	24	25	26	28	29	30	32	33	34	36	37	38
6'2"	187.9		12	13	14	15	17	18	19	21	22	23	24	26	27	28	30	31	32	33	35	36	37
6'3"	190.5		11	13	14	15	16	18	19	20	21	23	24	25	26	28	29	30	31	33	34	35	36
6'4"	193.0		11	12	13	15	16	17	18	19	21	22	23	24	26	27	28	29	30	32	33	34	35
6'5"	195.5		11	12	13	14	15	17	18	19	20	21	23	24	25	26	27	28	30	31	32	33	34
6'6"	198.1		10	12	13	14	15	16	17	18	20	21	22	23	24	25	27	28	29	30	31	32	34
6'7"	200.6		10	11	12	14	15	16	17	18	19	20	21	23	24	25	26	27	28	29	30	32	33
6'8"	203.2		10	11	12	13	14	15	16	18	19	20	21	22	23	24	25	26	27	29	30	31	32
6'9"	205.7		10	11	12	13	14	15	16	17	18	19	20	21	24	24	25	26	27	28	29	30	31
6'10"	208.2		9	10	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
6'11"	210.8		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	25	26	27	28	29	30

Step 1:
73 kg x 0.5 units/kg =
36.4 units = TDD

Step 2:
36 / 2 = 18 glargine (basal)
18 nutritional / 3 meals =
6 units lispro q AC

18 units glargine q HS (basal)
and 6 units q AC
(bolus/nutritional) +
correctional insulin

QUESTION 8.

Your third admit comes in at 7 pm: a 75-year-old woman with a fragility hip fracture.

She has a history of Diabetes Mellitus Type 2 and is on Metformin ER 850 mg BID and Glargine Insulin 40 units q HS. Her BMI is 25 and her Hgb A1c is 7.0%.

She will be NPO for the procedure which is scheduled for 7 am in the morning.

Which of the following is the most appropriate insulin regimen to start while she is hospitalized for operative repair of her hip fracture?

A. Glargine insulin 40 units q HS
B. Glargine 30 units q HS
C. Glargine 30 units q HS and Lispro 10 units QAC
D. Glargine 15 units q HS and Lispro 5 units QAC

Notes on being NPO

- If NPH is your basal, need to reduce dose by 50% to avoid hypoglycemic from the insulin peak
- If glargine is your basal AND it is dosed at 50% of the TDD then NO NEED TO ADJUST for NPO
- Meal insulin orders instruct RN to hold if eating <50% of the meal or on full liquids. No need to hold back ordering.

QUESTION 9.

A 45-year-old man with no significant past medical history (because he never saw the doctor) is admitted to the trauma surgery service after sustaining a pelvic fracture in a motor vehicle accident versus motorcycle. You are consulted to manage his diabetes for the trauma surgery service.

His blood sugar on admission is 320 mg/dL and his creatinine is 0.9 mg/dL. His BMI is 33 and his weight is 110 kg. A Hgb A1c is 10.3%.

Which of the following is the most appropriate regimen to start in the hospital setting?

A. Glargine 55 units q HS and 18 units q AC plus correctional insulin
B. Glargine 28 units q HS and 9 units q AC plus correctional insulin
C. Glargine 15 units q HS and 5 units q AC plus correctional insulin
D. Glargine 22 units q HS and 7 units q AC plus correctional insulin

Step 1:

Calculate Total Daily Dose of Insulin

- BS on admission > 200 mg/dL
- Creatinine 0.9 mg/dL
- Age 45
- 0.5 units x 110 kg = 55 units TDD

Step 2:

Divide TDD into Basal and Bolus

55/2 = 27.5= 28 units glargine (basal)

28/3= 9.3= 9 units lispro (nutritional)

PLUS

Correctional sliding scale

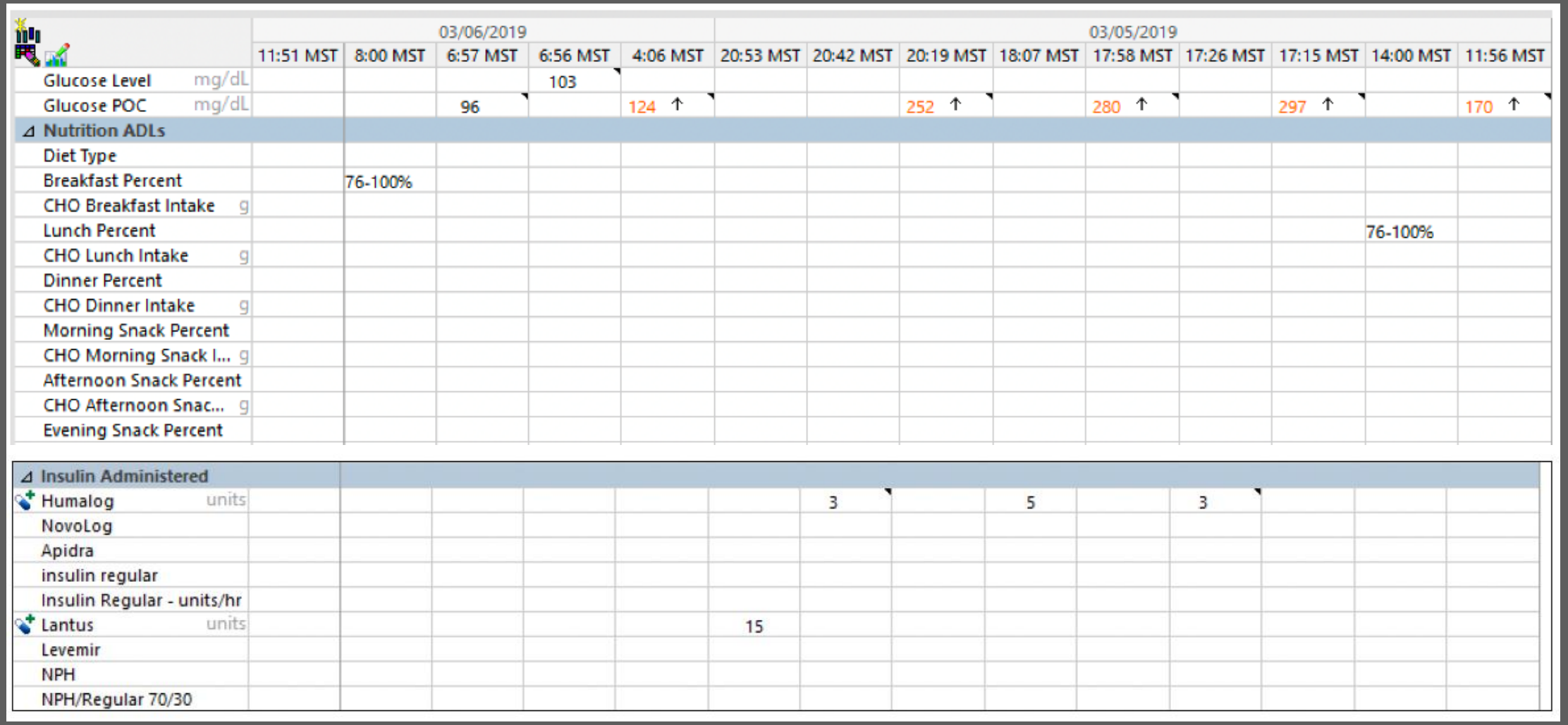
- Blood sugars should be checked q 6 hours in the hospital
- Usually this is done q HS (bedtime) and Q AC (before each meal)
- If the blood sugar is high ***prior*** to the patient eating the meal, they are given an ***additional amount of insulin*** (determined by the degree of hyperglycemia) ***in addition*** to the insulin to cover the meal.
- **THIS IS CALLED THE CORRECTIONAL INSULIN.**

CORRECTIONAL INSULIN AMOUNT *VARIES* WHETHER PATIENTS ARE INSULIN SENSITIVE OR INSULIN RESISTANT

	□ Insulin sensitive	□ Usual	□ Insulin resistant
Blood glucose (mg/dl)			
>141–180	2	4	6
181–220	4	6	8
221–260	6	8	10
261–300	8	10	12
301–350	10	12	14
351–400	12	14	16
>400	14	16	18

Check appropriate column and cross out other columns. The numbers in each column indicate the number of units of glulisine or regular insulin per dose. Supplemental dose is to be added to the scheduled dose of glulisine or regular insulin.

Diabetic Flowsheet in Cerner at BUMC-P



	03/06/2019					03/05/2019								
	11:51 MST	8:00 MST	6:57 MST	6:56 MST	4:06 MST	20:53 MST	20:42 MST	20:19 MST	18:07 MST	17:58 MST	17:26 MST	17:15 MST	14:00 MST	11:56 MST
Glucose Level mg/dL				103										
Glucose POC mg/dL			96		124 ↑			252 ↑		280 ↑		297 ↑		170 ↑
◿ Nutrition ADLs														
Diet Type														
Breakfast Percent		76-100%												
CHO Breakfast Intake g														
Lunch Percent													76-100%	
CHO Lunch Intake g														
Dinner Percent														
CHO Dinner Intake g														
Morning Snack Percent														
CHO Morning Snack I... g														
Afternoon Snack Percent														
CHO Afternoon Snac... g														
Evening Snack Percent														
◿ Insulin Administered														
Humalog units							3		5		3			
NovoLog														
Apidra														
insulin regular														
Insulin Regular - units/hr														
Lantus units						15								
Levemir														
NPH														
NPH/Regular 70/30														

QUESTION 10.

The trauma surgery resident sees you rounding on the patient.

She asks you, "What do you want the patient's blood sugar to be in the hospital? It seems kind of silly that just a few days of high blood sugars would be harmful or anything. Why don't we just send him to a primary care doctor when he is discharged?"

You know that good control of blood sugar in hospitalized patients is beneficial to ICU patients, medical patients, and surgical patients.

This is what you tell the resident:

A. "The goal fasting blood sugar is < 120 mg/dL and the goal random blood sugar is < 200 mg/dL."
B. "The goal fasting blood sugar is < 110 mg/dL and the goal random blood sugar is < 190 mg/dL."
C. "The goal fasting blood sugar is < 140 mg/dL and the goal random blood sugar is < 180 mg/dL."
D. "The goal fasting blood sugar is < 80 mg/dL and the goal random blood sugar is < 140mg/dL."

Table 1. Potential Harms of Uncontrolled Blood Glucose Levels in Hospitalized Patients with Type 2 Diabetes Mellitus

Potential harm	*Comment*
Increased risk of nosocomial and postoperative infections	After excluding minor urinary tract infections, a study of 97 patients found that those with a single blood glucose measurement of more than 220 mg per dL (12.2 mmol per L) on the first postoperative day had an increased risk of sepsis, pneumonia, and wound infection.[2]
Decreased neurologic recovery	Observational studies show an association between hyperglycemia and worsened outcomes in patients with acute stroke.[2]
Higher mortality associated with acute myocardial infarction	In a study of patients with acute myocardial infarction, the one-year mortality rate was 19.3% in patients with an admission blood glucose level < 101 mg per dL (5.6 mmol per L), compared with 44% in patients with an admission blood glucose level > 200 mg per dL (11.1 mmol per L).[1]
Longer length of hospitalization	In a study of patients undergoing lumbar spine surgery, the mean length of hospitalization was six days in those with uncontrolled diabetes, four days in those with controlled diabetes, and 3.7 days in those without diabetes ($P < .0001$ for both comparisons).[3]
Delayed procedures	Poor outcomes associated with hyperglycemia may lead to deferral of procedures until blood glucose levels are controlled, even when intravenous insulin can be used perioperatively.[3]

Information from references 1 through 3.

Target for Blood Sugar is 100 mg/dL-180 mg/dL in the Hospital Setting

Recommended glucose targets: ICU

❖ ADA/AACE:

Not recommended <110 mg/dl	Acceptable 110-140 mg/dl	Recommended 140-180 mg/dl	Not recommended >180 mg/dl

- Starting threshold no higher than 180 mg/dL
- Lower targets 110-140 mg/dL appropriate in select patients/institutions
- Targets <110 mg/dL or >180 mg/dL not recommended

❖ American College of Physicians: Recommended 140-200 mg/dl

❖ Critical Care Society: Recommended <150mg/dl

❖ Society of Thoracic Surgeons: Recommended <180 mg/dl, <150mg/dl (complications)

Moghissi ES, et al; AACE/ADA Inpatient Glycemic Control Consensus Panel. *Endocr Pract.* 2009;15(4).

Target glucose levels: non-ICU patients

❖ Floor setting:

- Pre-meal < 140 mg/dL
- Postprandial < 180 mg/dL
- Reassess regimen if BG < 100mg/dl
- OK to adjust target in setting of comorbidities
  - Renal, liver failure, hypoglycemia unawareness, heart failure

Adjust therapy <100 mg/dl	Pre-meal 100-140 mg/dl	Postprandial 140-180 mg/dl	Adjust therapy >180 mg/dl

Umpierrez et al. J Clin Endocrinol Metabol. 97(1):16-38, 2012

QUESTION 11.

You start the patient on 28 units of glargine q HS and 9 units of lispro q AC per insulin protocol along with a usual correctional sliding scale insulin. After 24 hours you reassess the blood sugars to see what they were every 6 hours by the diabetic flowsheet.

The sugars and medications were recorded as follows:

	3/12/2019 2200	3/12/2019 1800	3/12/2019 1200	3/12/2019 0600	3/11/2019 2200
BS-POC		300	240	185	220
Glargine (Basal)					28
Lispro (Nutritional)		9	9	9	
Lispro (Correctional)		12	8	4	

Which of the following is the most appropriate adjustment to be made to the patients insulin dosage now?

A. Glargine 30 q HS, Lispro 10 q AC, + correctional
B. Glargine 35 q HS, Lispro 15 q AC + correctional
C. Glargine 40 q HS, Lispro 20 Q AC + correctional
D. Glargine 48 q HS, Lispro 16 q AC + correctional

RABBIT 2 Surgery Titration

Fasting BG	Adjustment
100-140 mg/dL	No change
140-180 mg/dl	Increase TDD by 10% daily
>180 mg/dl	Increase TDD by 20% daily
70-99 mg/dl	Decrease TDD by 10%
<70 mg/dl	Decrease by 20%

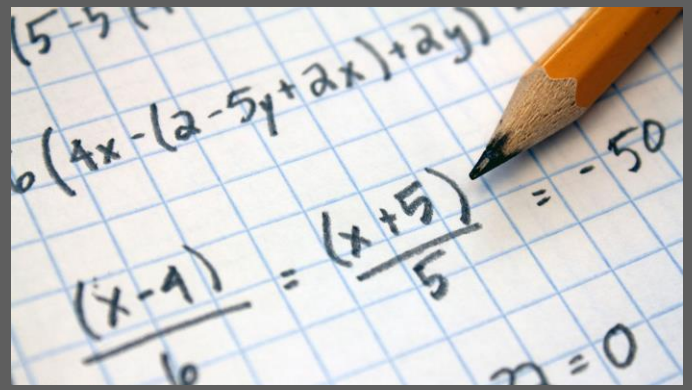
* Note: only increase the doses if NONE were <100mg/dl.

Daily Adjustments in Insulin Dose Based on Past 24 hour Blood Sugar Values

Step 1.
- Look at Blood Sugars for past 24 hours
- Notice any < 100 or > 180
- Calculate 24 hour insulin given (TDD)
- Any inappropriate insulin doses given or withheld?
- Adjust TDD up or down based on blood sugars, renal function, steroids, etc. (10-20% up or down)

Step 2.
- Separate new TDD into Basal and Bolus (50/50)
- Separate Bolus into 3 doses (QAC)
- Continue Correctional Sliding Scale
- Place new order

Show Your Work.
- TDD = 79 units
- All blood sugars > 180 therefore increase by 20%
- 79 x 1.20 = 94.8
- 95 / 2 = 47.5 = 48 glargine (basal)
- 48 / 3 = 16 units lispro (bolus)
- PLUS correctional sliding scale



QUESTION 12

The 35 year-old woman with cellulitis is treated with intravenous cefazolin and is improving daily. While at the hospital, she takes insulin glargine (18 units daily) and insulin aspart (6 units with each meal).

Laboratory studies on the day of discharge:

Hemoglobin A1c: 8.5%
Plasma glucose (fasting): 160 mg/dL
Serum creatinine: Normal

The patient has been giving appropriate diabetes education, has scheduled follow up evaluation, and states she is willing to take insulin if needed.

Which of the following regimens would best help this patient maintain good glucose control after discharge?

A. Refer to the primary care provider to prescribe diabetes medical regimen.

B. Continue the inpatient regimen of insulin glargine qHS and insulin aspart qAC

C. Start oral glipizide, 5 mg daily

D. Start oral metformin at 500 mg twice daily and add insulin glargine, 18 units daily.

What is the preferred management of diabetes in type diabetic patients after hospitalization?

- Prospective, multicenter open-label study aimed to determine the safety and efficacy of a hospital discharge algorithm based on A1c at admission.

2934 Diabetes Care Volume 37, November 2014

Hospital Discharge Algorithm Based on Admission HbA_{1c} for the Management of Patients With Type 2 Diabetes

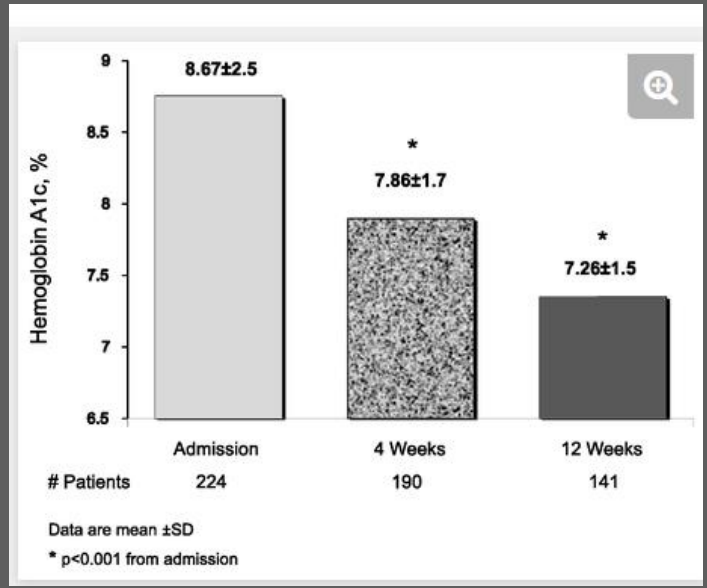
Guillermo E. Umpierrez,[1] David Reyes,[1] Dawn Smiley,[1] Kathie Hermayer,[2] Amna Khan,[3] Darin E. Olson,[1,4] Francisco Pasquel,[1] Sol Jacobs,[1] Christopher Newton,[1] Limin Peng,[5] and Vivian Fonseca[3]

Diabetes Care 2014;37:2934–2939 | DOI: 10.2337/dc14-0479

	A1c < 7%	A1c 7-9%	A1c > 9%
Hospital Discharge Regimen	Pre-admission therapy (oral or insulin therapy)	Pre-admission therapy + 50% TDD as glargine insulin	Pre-admission therapy + 80% glargine or basal bolus at 80% hospital TDD

- 224 patients, 12-week post discharge open label study
- Every 2 week phone call, 2 diabetes education meetings

- Results:
- A1c% decreased in 12 weeks by 1.5% with an acceptable rate of hypoglycemia



Questions?