

Johns Hopkins Hospital • Glucose Management Committee

PRESCRIBER TOOLS FOR INPATIENT DIABETES MANAGEMENT

2010

The Basal/Nutritional/Correctional Insulin Concept

- Basal insulin: 40 - 50% of Total Daily Dose (TDD) insulin
 - Long acting insulin required in all Type 1 and most Type 2 patients even when NPO (gluconeogenesis can serve as a continuous source of blood glucose)
 - Takes care of the minute to minute need for insulin throughout the day
- Nutritional Insulin: 20% of TDD at each meal
 - Rapid acting insulin given immediately after a meal or during tube feeds.
 - Takes care of the anticipated rise in blood sugar from absorbed carbohydrate
 - This dose is given even when the blood glucose is in the normal range
- Correctional Insulin:
 - Brings down blood sugar if it is too high
 - Given in addition to scheduled insulin
- Total Daily Dose (TDD): TDD includes all basal, nutritional, and correctional insulin over 24 hours

Type of Insulin	Starts	Peaks	Effective Duration
BASAL INSULIN			
Intermediate-Acting			
NPH (Novolin N, Humulin N)	2-4 hr	4-10 hr	12-18 hr
Long-Acting			
glargine (Lantus)	2-4 hr	None	20-24 hr
detemir (Levemir)	2-4 hr	None	20-24 hr*
NUTRITIONAL AND CORRECTIONAL INSULIN			
Rapid-Acting			
aspart (NovoLog)	5-15 min	30-90 min	4-6 hr
lispro (Humalog)	5-15 min	30-90 min	4-6 hr
glulisine (Apedra)	10-30 min	30-90 min	3-4 hr
Short-acting			
Regular (Novolin R, Humulin R)	30-60 min	2-3 hr	8-10 hr
MIXES			
NPH plus analog			
NovoLog Mix 70/30 (70% NPH, 30% aspart)	5-15 min	Dual	10-16 hr
Humalog Mix 75/25 (75% NPH, 25% lispro)	5-15 min	Dual	10-16 hr
Humalog Mix 50/50 (50% NPH, 50% lispro)	10-30 min	Dual	10-16 hr
NPH plus Regular			
Novolin 70/30 (70% NPH, 30% R)	30-60 min	Dual	10-16 hr
Humulin 70/30 (70% NPH, 30% R)	30-60 min	Dual	10-16 hr
Humulin 50/50 (50% NPH, 50% R)	30-60 min	Dual	10-16 hr

JHH formulary items

Sources: Hirsch, I. *NEJM* 352:174-183. 2005, Hirsch et al. *Clinical Diabetes* 23:78-86. 2005
Times are approximate only. Large variations between and within persons may be noted.

Converting from non-formulary insulins to formulary insulins

- Do not use Insulin U-500 inpatient. Consult endocrinology if home meds include U-500 insulin.
- **Lispro** and **glulisine** have a 1:1 dose conversion to aspart.
- **Regular** insulin has a 1:1 dose conversion to aspart, but will have a longer dosing frequency than aspart because of longer duration of action.
- **Detemir** has a 1:1 dose conversion to glargine.

Converting from 70/30 or other premixed insulins to glargine/ aspart regimen:

- Calculate total daily dose of insulin received from 70/30 or other premixed insulin.
- Give 40% of the total daily dose as glargine.
- The remaining 60% will be split into thirds, to be dosed as nutritional aspart with each meal.

STEPWISE APPROACH TO INITIAL MANAGEMENT OF INPATIENT HYPERGLYCEMIA

(Not Intended for patients with DKA, HHS, pregnancy, indication for IV insulin, or for those receiving CPN)

Glycemic Targets (mg/dL)

- Premeal:
 - 80-139 (most patients)
 - 100-150 (hypoglycemia risk factors)
- Random or Postprandial: <180

Step 1: Discontinue oral hypoglycemic agents for most patients

Review contraindications

Step 2: Determine whether the patient has any of the following characteristics:

≥ 2 BG values ≥ 180 mg/dL, Type 1 DM, already on insulin, or poorly controlled Type 2 DM on orals (A1c ≥ 7.5%)

Order Hg A1c

(If not avail. within last 2-3 months and no recent transfusion)

YES

NO

Step 3a: Estimate total daily dose (TDD) of insulin patient may require

TDD = Sum of a patient's estimated basal + nutritional insulin needs. 3 main methods of estimating:

- Add up TDD of insulin from patient's home regimen:** adjust ↓ or ↑ based on the quality of outpatient control, current degree of hyperglycemia, current patient status, and other factors
- Weight-based estimation:** (Choose an appropriate unit/kg/day estimation after reviewing the patient factors indicated below)
 - Malnourished, no history of DM, cognitive impairment, elderly, renal or liver dz., pancreatotomy **0.3 units/kg/day**
 - Lean (BMI 18.5-24.9) Type 2 DM, steroid-induced hyperglycemia, Type 1 DM **0.4 units/kg/day**
 - Overweight (BMI 25-30) Type 2 DM **0.5 units/kg/day**
 - Obese (BMI >30) Type 2 DM, or Type 2 DM receiving steroids **0.6 units/kg/day**
- From recent insulin infusion requirements:**
 - Sum the units of insulin infused over a 6hr period, then multiply x 4 → then multiply x 0.8 to get conservative estimate of 24h insulin need.
 - If NO source of glucose (e.g. D10, D20, parenteral or enteral nutrition) given to patient during infusion period from which estimate derived (preferred), then your estimate = patient's basal insulin needs → multiply x 2 to arrive at the TDD estimate
 - If patient was given a source of glucose during infusion period, then your estimate = patient's TDD
 - Accuracy of TDD estimate optimized in patients off pressors, with stable insulin infusion rate, renal function, and steroid dosage.

Step 3b: Initial management of mild hyperglycemia in non-insulin deficient patients

Mild hyperglycemia defined as intermittent BG values between 140-180 mg/dL, and no more than 1 BG ≥ 180 mg/dL.

- For initial therapy, order **LOW dose correctional scale** for 24-48 hr
- If > 20 units of correctional required within 24 hrs, or **2 or more BG values ≥ 180 mg/dL:**
 - Add up 24hr correctional doses = TDD estimate
 - Proceed to step 4

STEROIDS increase glycemic response to carbohydrate more than basal insulin needs.

- ON STEROIDS, decrease ratio of basal to nutritional insulin:
- 20 - 30% of TDD as basal
 - 70 - 80% of TDD as nutritional

Step 4: Divide the TDD into the appropriate components of insulin treatment depending on the patient's nutritional status

* Choose Correctional Scale Based on TDD

- < 40 units = **LOW** dose
- 41-80 units = **MEDIUM** dose
- > 80 units = **HIGH** dose

Eating meals OR receiving bolus tube feedings

Check glucose qac and qhs

Basal insulin: 40% of TDD

- If Glargine, give q 24 hrs, as time critical order
- If NPH, give 20% of TDD with b'fast, 20% of TDD qhs.

Nutritional insulin: 60% of TDD

- Provided as Aspart, given after each meal.
 - Divide dose equally by number of meals
 OR
 - Utilize carb counting and consult endocrine if pt does this at home.
- HOLD Dose if Nutritional Intake < 50%

Correctional insulin: MEALtime and BEDtime Aspart. Choose scale based on TDD*

NO enteral/parenteral nutrition OR on clear liquids

Check glucose q4h

Basal insulin: 40% of TDD

- If Glargine, give 40% of TDD q 24 hrs, as time critical order
- If NPH, give 20% of TDD qam, 20% of TDD qhs.

Nutritional insulin: None

Correctional insulin: q4h Aspart. Choose scale based on TDD*

Continuous tube feedings

Check glucose q4h

Basal insulin: 20% of TDD

- If Glargine, give 20% TDD q 24 hrs, as time critical order
- If NPH, give 10% of TDD with b'fast, 10% of TDD qhs.

Nutritional insulin: 80% of TDD

- Provided as Aspart, administered q4h
- Divide equally into 6 daily doses.
- Hold for BG < 100 mg/dL or if TF disrupted > 2 h

Correctional insulin: q4h Aspart. Choose scale based on TDD*

ADJUSTING INPATIENT SQ INSULIN

(Not Intended for patients with DKA, HHS, pregnancy, indication for IV insulin, or for those receiving CPN)

Glycemic Target Range
1. Premeal:
a) 80-139 (most patients)
b) 100-150 (hypoglycemia risk factors)
2. Random or Postprandial: <180

Review glycemic control over previous 24 hrs

Consider patient factors increasing risk of hypoglycemia:

If present, dose insulin conservatively

Steroid taper	Poor po intake	Changes in nutritional status	Adrenal insufficiency
Total pancreatectomy	Elderly	Acute or chronic renal disease	Liver disease
		Cognitive impairment	Sepsis

Bg's within target range (see bubble)

Are Any of the Following Patient Factors Present?

Rising Creatinine, pt being made NPO, or Steroid taper?

YES

NO

Rising creatinine

- Decrease TDD by 20%
- Consider switching to less aggressive correctional scale.

Patient made NPO

- Switch correctional scale to the NPO scale.
- If basal insulin dose is < 50% of TDD, decrease basal insulin by 20%.
- If basal insulin dose is > 50% of TDD, decrease basal insulin by 40%
- HOLD Nutritional insulin.
- Hang D5 ½ at KVO if multiple risk factors for hypoglycemia

Steroid taper

If fasting BG < 120, decrease the basal insulin dose by 10 - 20%

Continue current regimen

Am fasting bg within target, but BG's above target over course of day

- Continue current **BASAL** insulin dosing.
- Increase **NUTRITIONAL** insulin by 10 - 20%
OR
- Determine the total amount of **CORRECTIONAL** insulin that was required over the previous 24 hours.
- This amount can be split between **NUTRITIONAL** doses for the next day.

Bg's ABOVE target

Evaluate PATTERN of glucose elevation

Fasting BG elevated, and elevations continue throughout day

- If glucose consistently > 180 AND NO RISKS FOR HYPOGLYCEMIA (SEE ABOVE)
- increase TDD by 10 - 20%
 - distribute 40 % of TDD as basal insulin
 - provide the remaining 60% of TDD as nutritional aspart, dividing dose equally by number of meals
OR
 - Determine the total amount of **CORRECTIONAL** insulin that was required over the previous 24 hours.
 - This amount can be split between **BASAL** and **NUTRITIONAL** doses for the next day.
 - Approximately 40% can be added to the **BASAL** dose, and the remaining 60% can be split between the **NUTRITIONAL** doses.

Bg's labile or out of target range (see bubble)

Determine whether BG "lability" simply results from mistiming BG measurement in relation to meal intake or nutritional insulin administration (e.g. BG checked shortly after a meal, or nutritional insulin given and patient did not eat). If so, be conservative with dose changes, and discuss mistiming issues with nursing staff.

BG's BELOW target

Any episodes of hypoglycemia (BG ≤ 70)

Decrease TDD by 20%
Consider switching to a less aggressive **CORRECTIONAL** scale.

Premeal BG 70 - 80
(most patients)
OR

Premeal BG 70 - 100
(hypoglycemia risk factors)
Decrease TDD by 10 - 20%

≥ 2 episodes of **BG < 70** within 6 hours

Start D5 ½ NS at 75 cc/ hr
AND
Decrease TDD by 20%.

DETERMINING CORRECTION DOSE OF SQ ASPART INSULIN FOR BG > 350 MG/DL

Step 1: To avoid giving large insulin doses for a false high, send confirmatory lab if:

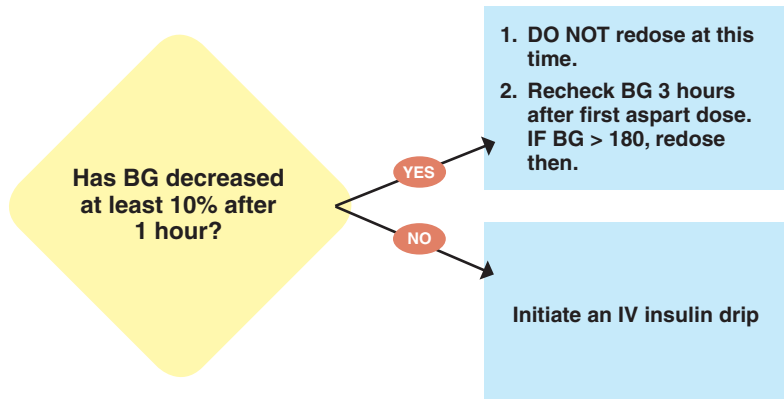
- point of care fingerstick reading is > 400
- BG elevation is inconsistent with the clinical picture

Step 2: Determine risk for DKA (e.g. Type 1 DM, pancreatectomy, Hx of DKA): If risk of DKA, send STAT BMP, plasma ketones prior to treating with sq insulin. If DKA confirmed patient must be treated with IV insulin.

Step 3: Based on the patient's Total Daily Dose (TDD) of insulin, choose SQ Aspart insulin correctional scale AFTER BG HAS BEEN CONFIRMED BY LAB.

TDD < 40 units		TDD 41 - 80 units		TDD 81 - 150 units		TDD > 150 units	
Insulin Sensitive (BMI < 25, Most Type 1 patients, elderly, kidney or liver disease)		Mild insulin resistance		Moderate insulin resistance		Marked insulin resistance	
BG	Units	BG	Units	BG	Units	BG	Units
351 - 400	6	351 - 380	8	351 - 390	14	351 - 400	17
401 - 450	7	381 - 410	9	391 - 430	16	401 - 450	22
451 - 500	8	411 - 440	10	431 - 470	18	451 - 500	27
501 - 550	9	441 - 470	11	471 - 510	20	501 - 550	32
551 - 600	10	471 - 500	12	511 - 550	22	551 - 600	37
> 600	11 AND START IV DRIP	501 - 530	13	551 - 600	24	> 600	42 AND START IV DRIP
		531 - 600	14	> 600	26 AND START IV DRIP		
		> 600	15 AND START IV DRIP				

Step 4: Check follow up BG 1 hour after SQ aspart dose to ensure BG is decreasing. DO NOT REDOSE SQ ASPART WITHIN 3 HOURS OF LAST SQ ASPART DOSE.



NON-INSULIN ANTIDIABETIC AGENTS

Slow onset of action

Varied duration of action in different individuals

Long action (frequently 24 hour duration)

} → Little flexibility, difficult to titrate in-house

***** NOTE : many of the contraindications develop unexpectedly during acute illness. For this reason, general recommendation is to discontinue oral agents during hospitalization**

Non-insulin agents can be continued in stable patients, with normal nutritional intake, adequate BG control, stable renal and cardiac function.

Generic and Class	Brand Name	Contraindications/ Cautions	Side effects
Sulfonylureas			
Glimepiride	Amaryl	Contraindications: DKA, NPO status.	Hypoglycemia, weight gain, potential increased risk of cardiovascular mortality
Glipizide	Glucotrol	Cautions: Risk of prolonged/ severe hypoglycemia if caloric intake is reduced. Long action with varied duration of action in different individuals. Increased risk of hypoglycemia in renal or hepatic impairment and elderly. Greatest benefit achieved at half maximum dose. Dose modification required with glimepiride and glyburide due to renal elimination. Less pronounced effect with glipizide.	
Glyburide	Diabeta Micronase Glynase		
Biguanides			
Metformin	Glucophage Fortamet Glumetza Riomet (liquid formulation)	Contraindications: 1) serum creatinine levels >1.5 mg/dL (males), >1.4 mg/dL (females) 2) metabolic acidosis, including DKA. 3) For studies involving iodinated contrast materials, discontinue at the time of or prior to the procedure, and withhold for 48 hours after the procedure. Cautions: advanced age, excessive alcohol intake, hepatic disease, hypoxemia, surgery.	GI symptoms common: diarrhea, nausea, flatulence, indigestion
Thiazolidinediones (TZD's)			
Pioglitazone	Actos	Contraindications: Heart failure NYHA Class III or IV. Cautions: Can increase intravascular volume, worsening edema or exacerbating HF. Do not use if baseline ALT >2.5X upper limit of normal or active liver disease. Slow onset of effect (8-12 weeks). Actos has favorable lipid profile, Avandia has negative lipid profile.	Weight gain, edema. See literature re: risk of myocardial ischemic events.
Rosiglitazone	Avandia		
Alpha-Glucosidase inhibitors			
Acarbose	Precose	Contraindications: cirrhosis, intestinal diseases associated with decreased absorption or digestion, DKA, bowel obstruction Cautions: Because alpha glucosidase inhibitors impair GI absorption of carbohydrates, any hypoglycemia must be treated with pure glucose, not food or drink → safety risk inpatient	Abdominal bloating, diarrhea, and flatus
Miglitol	Glyset		
DPP-4 Inhibitors			
Sitagliptin	Januvia	Contraindications: Type 1 DM, DKA. Cautions: Renal impairment (renal dosing), severe hepatic disease, pancreatitis. Has not been approved for use with insulin. No data to support use in acute care setting.	Headache, nasopharyngitis, URI
Saxagliptin	Olglyza		
Incretin Mimetics (SQ injectables, not available as po meds)			
Exenatide	Byetta	Contraindications: Type 1 DM, DKA, pancreatitis Cautions: Renal impairment, hypovolemia, gastroparesis or other GI disorders. Has not been approved for use with insulin. No data to support use in acute care setting.	Diarrhea, indigestion, nausea, vomiting. Rare: acute pancreatitis. Hypoglycemia risk increased when used with insulin secretagogues.
Liraglutide	Victoza		
Non sulfonylurea Secretagogues			
Nateglinide	Starlix	Contraindications: DKA, type 1 diabetes. Cautions: moderate to severe hepatic disease, elderly, malnourished, hepatic or renal insufficiency	Hypoglycemia, diarrhea, nausea
Repaglinide	Prandin	Contraindications: DKA, type 1 diabetes Cautions: Not for use with NPH insulin (severe cardiovascular events possible). Elderly, malnourished, hepatic or renal insufficiency	
Amylin analog (SQ injectables, not available as po med)			
Pramlintide	Symlin	Contraindications: gastroparesis, hypoglycemia unawareness, poor compliance. Cautions: CrCl < 20 ml/min, HbA1C > 9%	Abdominal pain, loss of appetite, nausea, vomiting, headache, fatigue, anorexia.
Bile acid sequestrant			
Colesevalam	Welchol	Contraindications: Bowel obstruction, Serum TG > 500 mg/dL. H/o hypertriglyceridemia induced pancreatitis. Cautions: swallowing disorders or dysphagia, phenylketonurics, TG > 300 mg/dL. GI motility disorders, fat soluble vitamin deficiencies.	Constipation, dyspepsia, abdominal pain, nausea.

INSULIN PUMPS IN THE HOSPITAL

SAFETY CONCERNS

Pt must be fully able to self manage their own insulin pump. If not, pump must come off after alternative insulin is ordered.

DKA is likely if there is pump interruption.

Alternative SQ or IV insulin orders must be written immediately to avoid DKA:

- if pump malfunctions (indicated by BG > 250 not declining within 1 hour after pump boluses)
- if patient is no longer able to manage insulin pump (e.g., confusion or sudden changes in medical or psychiatric condition, patient is unable to provide external SQ insulin pump supplies when needed).

ADMITTING A PATIENT WHO USES AN INSULIN PUMP

1. See “Insulin Pump” policy on Hopkins Policy On-Line website:
<http://www.insidehopkinsmedicine.org/hpo/>
2. Ensure that patient has signed the Patient Agreement (Appendix A)
3. Evaluate that there are no contraindications to pump use (Appendix B)
4. Write an order using the “Insulin Pump External SQ” orderset in POE or the paper version (Appendix D).
 - a. Consider patient’s home self reported pump settings (provided by patient on Appendix C) to determine initial inpatient pump orders. Adjust ↑ or ↓ based on home glycemic control, current status, other patient factors affecting insulin sensitivity.
 - b. Pt must use pharmacy provided aspart while in house. Aspart has a one-to-one conversion with lispro (Humalog) and glulisine (Apidra).
5. Ensure hypoglycemia interventions are ordered
6. Initiate Endocrine or Inpatient Diabetes Management Service (IDMS) consult (recommended), by typing “diabetes” in pager box.

PUMPS AND EXTERNAL RADIATION

- External Insulin Pumps cannot be exposed to external radiation.
- If a patient undergoes a brief X-ray, insulin pump can temporarily be disconnected and held outside the room until X-ray is finished. Pump should then be promptly reconnected. Pump should not be disconnected > 1 hr without alternative insulin available.
- If patient is transported to procedural area, staff in that area will follow a separate procedural area pump orderset.

KEY COMPONENTS OF INSULIN PUMP SETTINGS:

BASAL RATE: The rate at which rapid acting insulin is delivered as a continuous subcutaneous flow: expressed as units/ hour. The patient may have multiple basal rates programmed during the 24 hour period.

CARBOHYDRATE RATIO: The predicted amount of insulin needed per gram of carbohydrate for a specific meal or snack. (e.g., 1 unit insulin needed for 10 grams of carbohydrate)

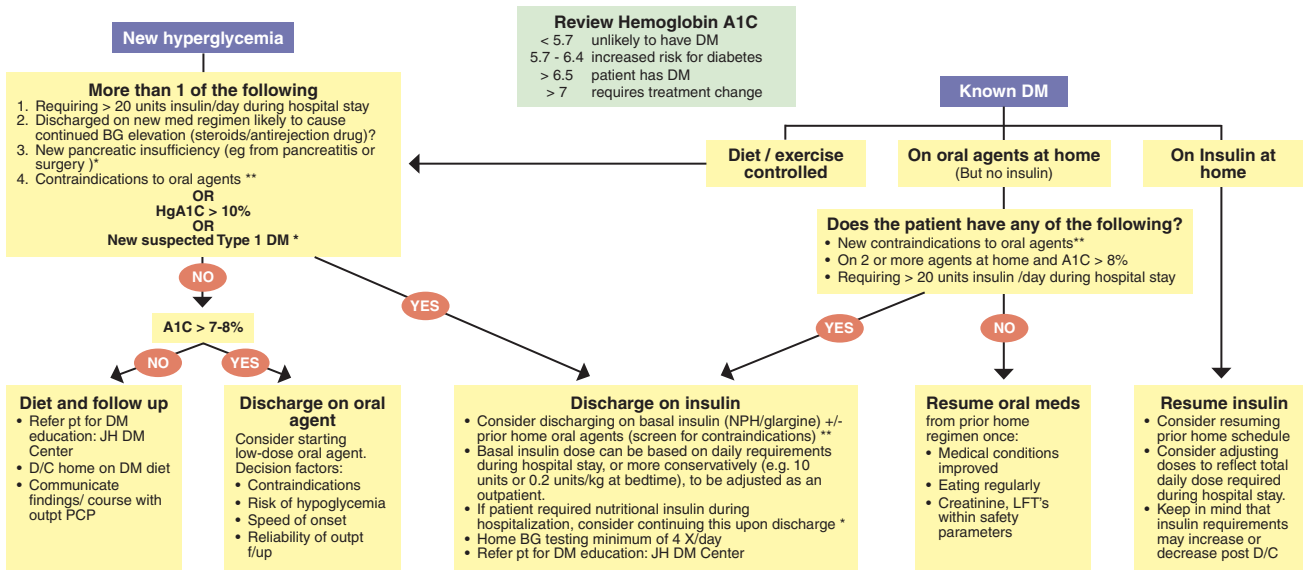
CORRECTION OR SENSITIVITY FACTOR: The amount that blood glucose (mg/dL or mmol/L) will be reduced by 1 unit of insulin. (e.g a correction factor of 50 means that 1 unit of insulin will reduce BG by 50 mg/dL)

TO CONVERT INSULIN PUMP SETTINGS TO SQ INSULIN INJECTIONS:

- 1: Determine the basal insulin injection dose (glargine or NPH):
 - Calculate the basal insulin dose by multiplying the hourly basal rate by 24.
 - Provide the calculated basal insulin dose as daily glargine (preferred) or NPH before b-fast and at bedtime.
- 2: Determine the nutritional aspart injection dose:
 - Maintain the carbohydrate ratio in the nutritional aspart order from the insulin orderset (eg: if patient has Carb ratio of 1 unit of insulin for every 15 carbohydrates eaten and is on 60 gram CHO diet, order 4 units of NUTRITIONAL aspart per meal.)
- 3: Determine the correctional aspart injection scale:

SENSITIVITY OR CORRECTION FACTOR (SETTING ON PUMP)	CORRECTIONAL ASPART SCALE TO CHOOSE FROM INSULIN ORDERSET
> 50	LOW dose
25 - 50	MEDIUM dose
< 25	HIGH dose

TRANSITIONING TO A HOME REGIMEN FOR PATIENTS WITH HYPERGLYCEMIA DURING HOSPITALIZATION



If patient is sent home on any change in regimen :

1. Minimum of 24 hour In-house trial of discharge regimen prior to discharge.
2. Must consider motivations and capabilities of individual and family: Can they understand/ be trained?
3. Pt/family must get involved early.
4. Rationale for approach should be shared
5. Confusion regarding changes from home regimen must be countered by extra education. Reconcile meds.
6. Arrange f/up appt with PCP and/or Endo ≤ 2 weeks of discharge
7. Direct Communication with outpatient PCP is essential

Converting from glargine/aspart regimen to outpatient 70/30 regimen (or other premixed insulin)

- Calculate total daily dose of insulin received .
- Give 50 - 60% of the total daily dose as 70/30 (or other premixed insulin) with breakfast.
- Give the remaining 40 - 50% of the total daily dose as 70/30 (or other premixed insulin) with dinner.

* **NOTE:** any patient following TOTAL pancreatectomy, or with newly diagnosed Type 1 DM will always require basal/nutritional and correctional insulin on discharge

** e.g. renal insufficiency, abnormal LFT's, CHF