Insulin Algorithm for Type 2 Diabetes Mellitus in Children and Adults

**Once-daily Insulin Therapy**
- Morning – Basal insulin
- Bedtime – Basal insulin or NPH

**Before supper (Evening)**
- NPH + R or F 2:1 ratio
- Premix 70/30 or 75/25

**Starting dose**
- 0.1-0.25 units/kg/day or 6-10 units/day if patient is elderly or thin

**Achieving Goals**
- Adjust Basal insulin / Bedtime NPH based on FPG
- Adjust NPH + R or F / Premix based on bedtime glucose and FPG

**Titration schedule**
- Add 1 unit of insulin each day to reach glycemic goals OR
- If FPG:
  - >180 mg/dL: Add 6 units
  - 141-180 mg/dL: Add 4 units
  - 121-140 mg/dL: Add 2 units
  - 100-120 mg/dL: Add 1 unit
  - 80-99 mg/dL: No change
  - <80 mg/dL: Subtract 2 units

**Multi-dose Insulin Therapy (MDI)**
- 2 injections
  - NPH with R or F (ratio 2:1) before AM and evening meal
  - Premix 70/30 or 75/25 before AM and evening meal
- 3 injections
  - Especially if nocturnal hypoglycemia
  - NPH with R or F morning; R or F evening; NPH bedtime or Premix (as above) morning, noon, evening

**Starting dose**
- 0.3-0.5 units/kg/day, divided as follows:
  - 2 injections: 2/3 morning; 1/3 evening
  - 3 injections: Premix: 1/3 morning; 1/3 noon; 1/3 evening
  - NPH + R or F:

**Follow A1c every 3-6 months and Adjust Regimen to Maintain Glycemic Goals**

**Intensive Insulin Management**
- Basal: Once-daily, either morning or bedtime (alternative: NPH morning and bedtime)
- Bolus: Fast-acting insulin before each meal; (alternative: R may be used)

**Premeal insulin dose includes:**
1. Insulin to cover carbohydrate ingested &
2. Additional insulin to correct for high SMBG:
   - 1 extra unit premixed insulin (mg/dL)
   - ~1500/TDD for Regular
   - ~1800/TDD for Aspart/Glulisine/Lispro

**Starting dose**
- 0.3-0.5 units/kg/day (1:1 basal:bolus ratio SQ)
  - Or
- 2. If current dose >0.5 units/kg/day
  - Basal dose = 80% Total daily NPH or 80% Total long-acting component of premix
  - Bolus dose = 80% of basal dose divided between 3 meals

**Footnotes**
2. Current glucose meters give values corrected to plasma glucose.
3. May also begin combination oral agent therapy. See Glycemic Control Algorithm for Type 2 Diabetes Mellitus in Children and Adults.
4. Combining metformin with insulin therapy has been shown to result in less weight gain and better glycemic control with lower insulin requirements.
5. Continue combination oral agent therapy + sulfonylurea.
6. Continue metformin (≤3rd oral agent); probably discontinue sulfonylurea.
7. Fast-acting insulin is given with the start of each meal. Regular insulin to be given 30-60 minutes before meals.
8. Dosage may differ in children and adolescents; consider referral to pediatric endocrinologist/comprehensive diabetes specialty team.
9. Start lower and increase slower for thin/elderly/complicated patients.
10. Consider referral to pediatric/adult endocrinologist/diabetes specialty team (option—insulin pump, Pramlintide).
11. Typical “carb” bolus = 1 unit bolus insulin covers 500/TDD x g carbohydrate from meal (~10-15 g); strongly recommend referral to Registered/Licensed Dietitian or Certified Diabetes Educator with experience in diabetes nutrition counseling (see Worksheet D).

See disclaimer at www.tdctoolkit.org/algorithms_and_guidelines.asp
Initiation of Once Daily Insulin Therapy for Type 2 Diabetes Mellitus in Children and Adults

Glycemic Goals

<table>
<thead>
<tr>
<th>A1c</th>
<th>FPG</th>
<th>2h PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤6%</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>&lt;7%</td>
<td>120</td>
<td>180</td>
</tr>
<tr>
<td>&lt;8%</td>
<td>140</td>
<td>180</td>
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</table>

Treatment Naïve:

A1c ≥10% or A1c <10% when considering early insulin initiation

If ketoacidosis or recent rapid weight loss, see Type 1 Diabetes algorithm

Oral Agent Failure;

A1c above target

Initiate Insulin Therapy with daily Glargine or Detemir or bedtime NPH

Beginning Dosage: 10 units or 0.1–0.25 units/Kg

Suggested Titration Schedule – Adjust Every 2-3 Days

If FPG:

- >180 mg/dL: Add 6 units
- 141–180 mg/dL: Add 4 units OR Add 1 unit insulin each day until fasting SMBG is at goal
- 121–140 mg/dL: Add 2 units
- 100–120 mg/dL: Add 1 unit
- 80–99 mg/dL: No change
- <80 mg/dL: Subtract 2 units

If A1c remains >A1c goal over 3 months, discontinue oral secretagogue, continue oral insulin sensitizer(s) and initiate multi-dose insulin or intensive insulin therapy or consult an endocrinologist

Footnotes

1 For the complete approach to insulin initiation in Type 2 Diabetes Mellitus, see Insulin Algorithm for Type 2 Diabetes Mellitus in Children and Adults.


3 Current glucose meters give values corrected to plasma glucose.

4 Usually with an insulin secretagogue (sulfonylurea, repaglinide or nateglinide) and sensitizer (metformin or thiazolidinedione). See Glycemic Control Algorithm.

5 The pharmacokinetic profile of NPH compared to that of glargine or detemir is less predictable, therefore can result in blood sugar variations and increased nocturnal hypoglycemia. Cost of glargine or detemir is 1.5-2 times that of NPH. Lispro 75/25 or Aspart 70/30 can be considered at pre-supper adjusting dosage according to HS and fasting SMBG.

6 IMPORTANT: See package insert for dosing.

7 If daytime hypoglycemia develops, contact healthcare professional.

Abbreviations:

FPG: Fasting plasma glucose
SMBG: Self-monitored blood glucose
PP: Postprandial plasma glucose

Diabetes treatment algorithms

A. Conversion from once-daily insulin to intensive/physiologic insulin replacement:

Oral therapy failure: Once-daily glargine was added to the oral regimen and titrated to 30 units per day. How do you add analog insulin if the patient reports the following SMBG values?

<table>
<thead>
<tr>
<th></th>
<th>FPG</th>
<th>2-HR PP BRKFT</th>
<th>2-HR PP LUNCH</th>
<th>2-HR PP DINNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>105</td>
<td>140</td>
<td>140</td>
<td>240</td>
</tr>
<tr>
<td>Case 2</td>
<td>105</td>
<td>140</td>
<td>190</td>
<td>240</td>
</tr>
<tr>
<td>Case 3</td>
<td>105</td>
<td>190</td>
<td>240</td>
<td>240</td>
</tr>
</tbody>
</table>

Case 1
a. Continue the oral agents (± sulfonylurea) and 30 units glargine or detemir (or NPH)
b. There are 2 approaches for adding analog (RAI) 10-15 minutes before a meal:

#1 Arbitrary start: 5 units
   Titrate: Add 2 units every 2 days to reach 2-hr pp goal

#2 Carb-counting 1 unit/50 mg/dL over 2-hr pp goal
   PLUS
   1 unit/15 grams carbohydrate
   Titrate: Add 1 unit/50 mg/dL >2-hr pp goal every 2 days

Cases 2 and 3
As above, but add and titrate analog before each meal where the postprandial glucose is above goal. Also, see part D below for more information on how to optimize the use of analog insulin. Re-evaluate each week to be certain that about half of the total daily dose is basal and half is bolus insulin.

B. Conversion from once-daily premix to intensive/physiologic insulin replacement:

Oral therapy failure: Once-daily 70/30 premixed insulin was added and titrated to 30 units per day. The fasting glucose is at goal, but daytime control is poor. How do you convert to physiologic insulin therapy?
a. **Basal insulin dose:** The first step in the conversion is based on the total dose of intermediate-acting insulin. In this case, the person is taking 21 units of NPH or aspart-protamine insulin (70% x 30 units = 21 units). So, give 21 units basal glargine (use “unit-for-unit” conversion for once-daily intermediate regimens). *Remember, do not stop oral agents (+ sulfonylurea) at this time.*

b. **Bolus insulin dose:** There are several ways to start the analog.
   
i. **See Case 1 (Arbitrary start or Carb-counting)**

   ii. Begin with the previous dose of fast-acting insulin, divide it before meals and titrate every 2 days. In this case, the person was using 30 units of 70/30 or about 9 units of fast-acting insulin (30% x 30 units = 9 units). So give 3 units of analog before each meal and titrate every 2 days as per Case 1.

C. **Conversion from twice-daily premix to intensive/physiologic insulin replacement:**

Oral therapy failure in an 80 kg person: 70/30 premixed insulin was started and advanced to 60 units per day: 40 units before breakfast and 20 units before dinner. The fasting glucose was at goal, but wide glycemic excursions occurred at other times during the day and night. How do you convert this person to physiologic insulin therapy? There are several approaches. Use which ever method you want.

a. **Start over and begin insulin at 0.5 units/kg.** Give half as basal insulin and half as analog, divided before meals. In this case, the starting dose would be 40 units per day. Start giving 20 units glargine each morning and about 7 units analog before each meal. Titrate the basal and bolus insulins every 2 days to fasting and 2-hr postprandial goals.

b. **Conversion based on current insulin usage:**

   **Basal dose:** The first step in the conversion is based on the 80% of the total dose of intermediate-acting insulin. In this case, the person is taking 42 units of NPH or aspart-protamine insulin (70% x 60 units = 42 units). When a person is taking multiple doses of intermediate-acting insulin, we give only 80% as glargine. So, give 34 units basal glargine (80% x 42 = 34). *Remember, do not stop oral agents (+ sulfonylurea) at this time.*

   **Bolus insulin dose:** There are several ways to start the analog.

   i. **See Case 1 (Arbitrary start or Carb-counting)**

   ii. Begin with the previous dose of fast-acting insulin, divide it before meals and titrate every 2 days. In this case, the person was using 60 units of 70/30 or 18 units of fast-acting insulin (30% x 60 units = 18 units). So, give 6 units of analog before each meal and titrate every 2 days as per Case 1.

c. **The “80%-80%” rule:** Similar to the above method, but yields an ideal ratio of basal:bolus insulin in one step. The dose of basal glargine will be 80% of the total intermediate insulin, and the analog will be 80% of the glargine dose, divided before meals.
Basal dose:  
= 80% of total intermediate insulin  
= 80% x 42 units (70% x 60 = 42)  
= 34 units glargine

Analog dose:  
= 80% of the glargine dose, divided TID  
= 80% x 34 units = 27 units  
= 27 units, divided TID = 9 units  
= 9 units aspart, glulisine or lispro before meals

Note: Total dose of insulin is conserved and an ideal ratio between basal and bolus will always result with the “80%-80%” method.

D. Optimizing analog insulin use

Tight control of blood glucose requires that the patient participates in the management of their diabetes. This includes monitoring their blood glucose and learning to count carbohydrates or “carb count.” The following material explains how to calculate the dose of analog required to cover a meal and how to add extra analog to correct a hyperglycemic event.

a. Determining the dose of analog insulin to use before a meal

The “Rule of 500” is used to determine how many grams of carbohydrate 1 unit of analog insulin will cover. When this number is known, then the person can easily give the correct dose of analog by simply counting the grams of carbohydrate they intend to eat at the meal.

Specifically, 500 divided by the total daily insulin dose (500/TDI) yields the number of grams of carbohydrate that 1 unit of analog will cover. For example, if a person has established that they require about 50 units of insulin per day, then it follows that 1 unit of analog will cover 10 grams of carbohydrate (500/50 = 10). If the person carb counts 140 grams in the dinner meal, then the dose of analog will be 14 units given 10 minutes before eating.

b. Correcting for hyperglycemia

The “Rule of 1800” is used to determine how much insulin to use to bring a high glucose reading back to goal. Even with tight control, hyperglycemia occurs and people need to be able to correct this situation.

Specifically, 1800 divided by the total daily insulin dose yields a value indicating how much 1 unit of analog insulin will lower the blood glucose. Thus, if a person uses 90 units of insulin per day, then 1 unit of analog will reduce the blood glucose by 20 mg/dL (1800/90 = 20). This augment dose of insulin can be used by itself to correct hyperglycemia, or added to the bolus dose if glucose is high before a meal.
References

2. Spellman CW, Renda SM, Davis SN. Realizing the Potential of Insulin Therapy in Type 2 Diabetes: A Case Presentation-Based Monograph. presented at the American College of Osteopathic Internists 64th Annual Convention; Chicago, IL (September 30, 2004).

Reviews/Important Articles

• DeWitt DE, Hirsch IB. Outpatient insulin therapy in type 1 and type 2 diabetes mellitus: scientific review. JAMAA. 2003;289(17):2254-64.

Once Daily Insulin

Morning vs. Bedtime NPH

Morning vs. Bedtime Glargine

NPH vs. Glargine

Once Daily vs. Twice Daily Regimen


Multiple Dose Insulin Regimens (2-shot Regimens)

NPH/Regular vs. NPH/ short acting analogue therapy

70% NPH/ 30% Regular vs. Humalog Mix 75/25™ or Novolog Mix 70/30™

Multiple Dose Insulin Regimens (3-shot Regimens)


Intensive Insulin Therapy