

TYPE 1 DIABETES, DIET PLANNING AND CARBOHYDRATE COUNTING

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TYPE 1 DIABETES MELLITUS (T1DM)

- Autoimmunity directed at beta cells in pancreas.
- Discovery of insulin (1921): converted T1DM from a fatal to a chronic disease (with considerable morbidity).
- Insulin Rx is imperfect. (impossible to mimic pattern of endogenous insulin production)
- Difficult to achieve normal metabolic milieu → swings in BG & risk of early micro & macrovascular complications

**GOOD DIABETES CONTROL:
GOOD HbA_{1c} WITHOUT HYPO**

INSULIN

**MEAL
PLANNING**

**PLANNED
EXERCISE**

**THERAPEUTIC
MONITORING**

PATIENT EDUCATION, EMOTIONAL STABILITY

DIET PLANNING IN T1DM: AIMS

1. **Quantity:** for normal growth & development.
2. **Quality:** to prevent or delay, micro & macrovascular complications.
3. **Match food, insulin & physical activity:** for smooth BG control (good HbA1c with low SD).
4. **Plan for hypoglycemia prevention & for sick days.**

1. ENSURE PROPER QUANTITY

- Extra calories at diagnosis & during recovery from DKA.
- Calorie requirement (after stabilization):
 - 1st 10 kg : 100 cal/kg.,
 - 11-20 kg : 50 cal/kg extra,
 - >20 kg : 20 cal/kg extra.
- Appetite + weight gain (growth charting): best indicators.

EXCESS WEIGHT GAIN

1. Frequent hypos with over-Rx. / Excess eating to prevent hypo.
2. Overeating / binge eating + over insulinization.
3. Hypothyroidism (wt gain with loss of appetite).

WEIGHT LOSS / INADEQUATE GAIN.

1. Poorly controlled diabetes.
2. Dieting / omission of insulin to lose wt.
3. Ass. chronic disease (TB) / co-morbidity: celiac disease, Addison's disease, hyperthyroidism.

2. ENSURE PROPER QUALITY (DIABETES DIET=HEALTHY EATING)

- In the absence of: celiac disease, hyperlipidemia, microalbuminuria or hypertension.....
- Children with T1DM, should eat what any normal child of same age, sex, race & built should eat.
- The entire family must have the same meals (for their own health & for child's compliance).

FATS

25-30% (<35%) OF TOTAL CALORIES

Saturated fats (<10%): raise LDL-C. (<7% if LDL-C >100 mg%). *Cholesterol*: <300 mg/day (<200 if LDL-C raised)

Monounsaturated fats (10-15%): improve LDL-C.

PUFA ($\leq 10\%$):

- Omega-6 : reduces LDL-C
- Omega-3 : reduces TG & blood viscosity. (oily fish 80-120 gm 2 times a week if TG is raised).

Trans fats: avoid.

IMPORTANCE OF MONITORING FAT INTAKE & LIPID LEVELS

- Macrovascular complications occur earlier & are more severe in T1DM patients
- Reduction of TC or LDL-C by 40 mg/dl reduces risk by 15% and 18% resp.

PHYTOSTEROLS

- Found in plant cell membranes, competitively block cholesterol absorption in gut.
- In hypercholesterolemia: can further lowers LDL-C 14%.
- Found in very small amounts in nuts, legumes, whole grains, fruits, veggies & veg. oils; (cannot provide > 0.5 gm); insufficient for lowering cholesterol; hence fortified foods or supplements needed.
- ADI in children: 130 mg/kg/day.

PROTEINS: (15 to \leq 20% of TOTAL CALS)

- High proteins can cause glomerular hyper filtration (plays a role in genesis of CRF), can impair growth; vitamin & mineral intake.
- Restrict to 10% in early nephropathy.
- Vegetable proteins (beans, legumes) less nephrotoxic (?) + lower in saturated fats, higher in fiber & complex carb.

SALT

- Moderation (diabetics prone to BP): 2 gm / 1000 kcal. (<1 yr: <1 gm salt; 1-3 yrs: 2.5 gm; 4-8 yrs: 3 gm; >9 yrs: 3.8 gm per day).
- Difficult, since stress is on salty foods.
- Restrict processed foods: canned or packaged foods, baked products, pickles, papad, sauces, chinese food.
- Use flavor enhancers : herbs, rock salt, lemon juice, vinegar, spices, onions, tamarind, green pepper.

3. MATCH FOOD & INSULIN: CARB COUNTING, PRINCIPLES

1. Carbs are the chief macronutrient that affect PP BG & determine insulin bolus dose.
2. Total carb (not kind of carb: starches or sugars) determines bolus insulin need.
3. After ingestion: carbs enter systemic circulation in 15 mins; transformed to glucose in 2 hrs

CARB COUNTING: THE EVIDENCE

- *Diabetic Medicine; July 2014; systematic review: studies using total carb in meal to adjust bolus insulin dose show:*
 - HbA1c reduction by 0-1.5%;
 - Improved QOL;
 - Significant reduction in hypoglycemia
 - No rise in incidence of hypoglycemia

THE 1ST STEP

CALCULATE CARB REQUIREMENT IN GRAMS / CARB CHOICES

1. Total calorie requirement = by formula: 1500 cal (assuming wt of 20 kg)
2. Calories from carb (50-60% of total calories) = total cal \times 0.5-0.6 \rightarrow 750-900 cal
3. Carb gm / day = cal from carb \div 4 (4 cal come from 1 gm carb) \rightarrow 190-225 gm carb
4. 1 carb choice = 15 gm.
5. No. of carb choices = carb gm / day \div 15 = 15 carb choices / day.

BASIC CARB COUNTING

- Distribute carb gm / choices between meals & snacks. Prepare individualized sample diet (based on preferred foods & timings of meals). Insulin plan to match this.
- Meal & snack timings & amt of carb for given meal to be fixed from day to day. Carb exchange list for variety with consistency.
- For patients on 1) split-mix regimen 2) MDI regimen with fixed insulin dose

BOLUS AND BASAL INSULINS

BOLUS

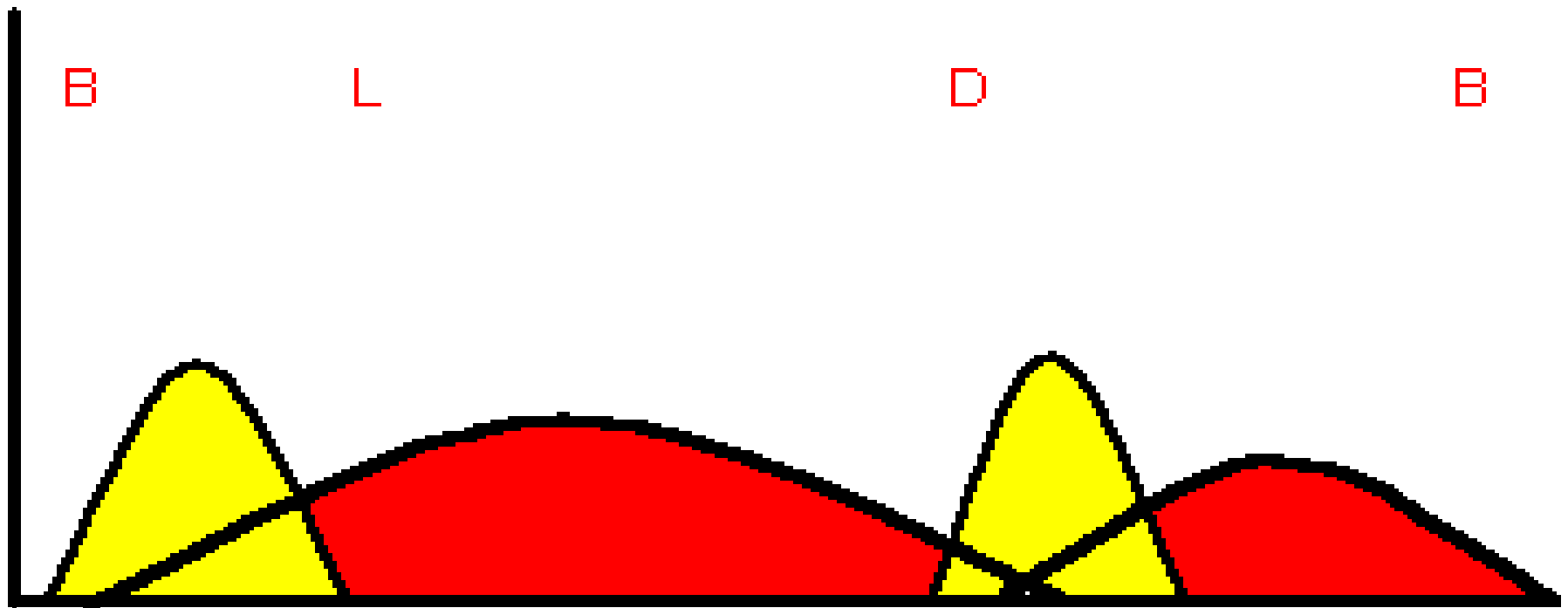
- Prevents abnormal BG rise following meals / correct BG above target.
- Given as 3-4 inj. of analogues: Aspart, Lispro, Glulisine; or 2-3 inj. of human regular.

BASAL

- Maintains BG in post-absorptive phase ; regulates neoglucogenesis and activity related BG fluctuations.
- Given as 1-2 inj of Glargine, Detemir, Degludec insulins (all peakless) or as human NPH (distinct peak at 5-8 hrs, erratic absorption)

SPLIT-MIX REGIMEN: (2 INJ. REGIMEN)

HUMAN REGULAR + NPH (twice a day)

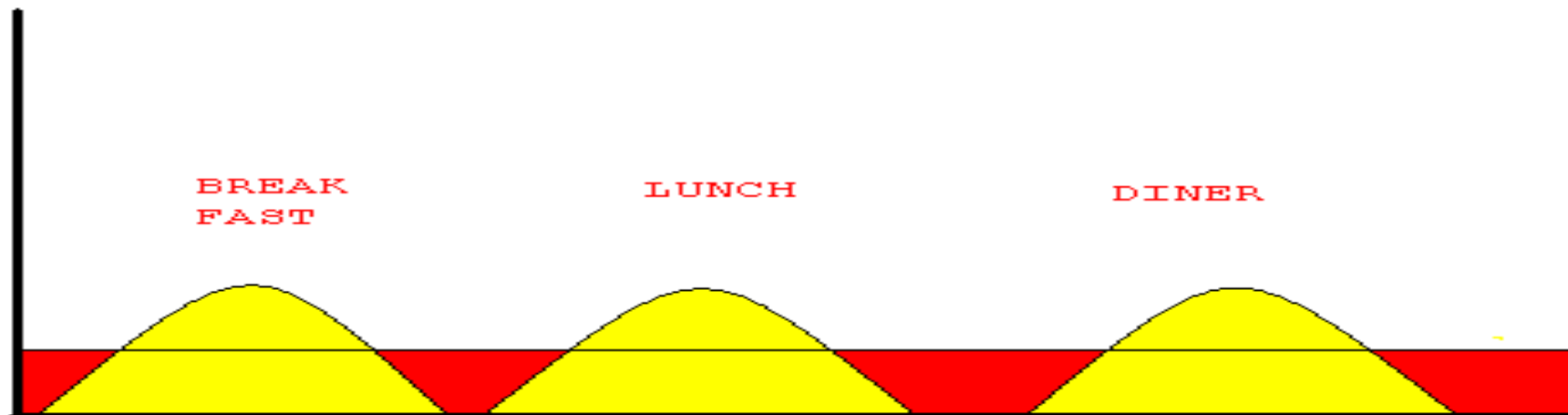


- 1 insulin covers 1 period (1 meal + 1 snack).
- Role of a low GI bedtime snack

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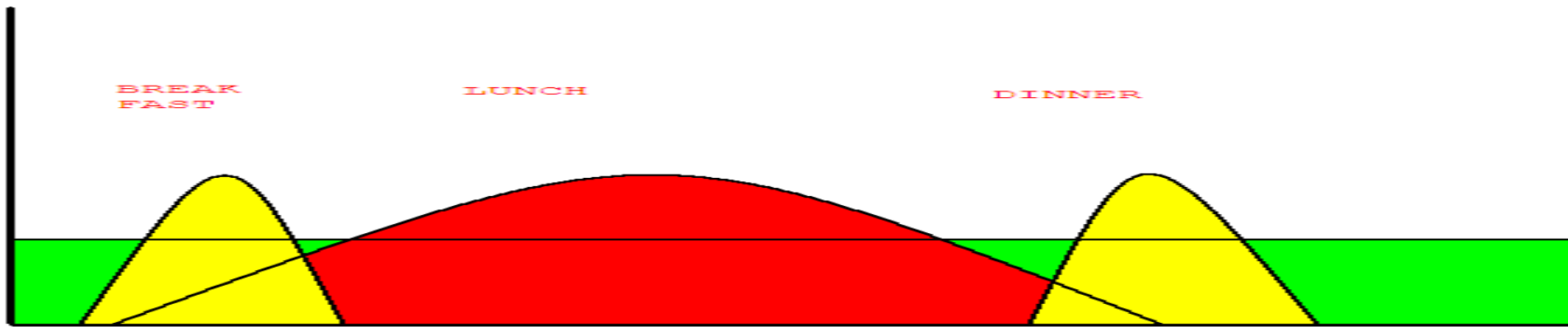
Dr. Aspi J. Irani.

FIXED DOSE PRE-MEAL BOLUSES (M.D.I. REGIMEN)



- Can afford basal analogue + ready for 4 shots + can take noon inj.
- Each bolus covers 1 meal +/- 1 snack
- Basal analogues are peakless

FIXED DOSES OF NPH WITH SHORT ACTING & BASAL ANALOGUES



- Cannot have noon shot; needs analogues for the night.
- Rapid acting analogues cover breakfast & dinner
- NPH peak covers lunch, evening snack
- Glargine / Detemir provides overnight basal

ADVANCED CARB COUNTING

- Freedom for meal timings & for carb content while keeping PP BG in control
- **Caution:** freedom must be coupled with responsibility (principles of good nutrition)

ADVANCED CARB COUNTING (NOT FOR EVERYONE)

1. Must be on MDI regimen with analogues OR on insulin pump (CSII).
2. Must test pre & post meal BG
3. Must learn A) how to count carbs, & B) how to calculate insulin bolus to match carb intake (using insulin dosing ratios ICR & ISF).

KNOW THE CARB CONTENT OF FOODS

- Know which foods contain carbs. (Note: "non-carb" foods like fish, meat may have added carb)
- Know quantity of carbs in foods.
 - Most people eat fixed set & amt of foods 80% of the time.
 - Prepare list of these items & prepare personal carb count database.
 - Use resource books, nutrition facts labels; restaurant fact sheets; internet sites.

NUTRITIVE SWEETENERS

- Sugars (sucrose & fructose): 4 gm carb (16 cal.) per level tsf. Fructose is twice as sweet as sucrose + lower GI (19 vs. 65).
- Sugar alcohols (sorbitol, xylitol): 2 gm carb (8 cal.) /tsf (partially absorbed). Thus $\frac{1}{2}$ the sugar alcohol gm can be subtracted from total carb.

FIBER

- Recommended intake > 2 yrs → 19-26 gm / 1000 cal. Soluble fiber (fruits, veggies, legumes) useful in lowering lipid levels.
- For food portions with ≥ 5 gm fiber, $\frac{1}{2}$ the fiber gm can be subtracted from total carbs.

IDENTIFYING PORTIONS OF CARB FOODS

- Weigh / measure food portions (at outset & then periodically).
- After weighing / measuring 15 gm portion of carb food, 1) put in cup or bowl 2) put in plate (what 15 gm carb portion look like in cup, bowl, plate).
- Food models in 15 gm carb sizes for education

UNCOOKED & COOKED WEIGHTS

- Starchy foods have different uncooked (dry) & cooked weights.
- Pasta absorbs water when cooked; (hence is heavier than its dry weight). Potatoes lose water when baked; (baked potato is lighter).
- Use timer to cook for consistent cooked wt.

THE HAND: FOR ESTIMATING FOOD PORTIONS

- **Palm, excluding fingers & thumb,** is ~ 3 oz of cooked, boneless meats.
- **Fist** is ~ 1 cup or ~ 30 grams carb for ice cream, cooked cereal or veggies, milk, salads.
- **Handful** is ~ $\frac{1}{2}$ cup or 120 ml of fruit, fruit juice, starchy vegetables.
- **Thumb** is ~ 1 tbsf of regular salad dressing, reduced-fat mayonnaise or reduced-fat margarine.
- **Thumb tip** is ~ 1 tsf or 5ml of margarine, butter, mayonnaise, other fats such as oils.

Computer vision-based carbohydrate estimation for type 1 patients with diabetes using smartphones.

[Anthimopoulos M](#), [Dehais J](#), [Shevchik S](#), [Ransford BH](#), [Duke D](#), [Diem P](#), [Mougiakakou S](#)
[J Diabetes Sci Technol](#). 2015 May;9(3):507-15.

- **GoCARB system:** a smart phone application, runs on 4 modules: 1) Food recognizer: different items on plate segmented & recognized from phone camera image; 2) Volume estimator: reconstructs 3 D image of the food & estimates it's volume; 3) Carb estimator: combines these results & uses a nutritional database to calculate carb content; 4) Insulin bolus estimator.

CALCULATE INSULIN CARB RATIO

- Insulin : Carb Ratio (ICR) = no of grams of carb that need 1 U bolus insulin
- Formula for ICR: $ICR = \frac{500}{TDD}$ (TDD: total daily dose of basal + bolus insulins)
- Fine tune the ratio.....

FINE TUNE ICR

- Aim: 2 hr PP BG should be 25-50 mg% over pre-meal value.
- If 2 hr PP BG >50 mg/dl above pre-meal value decrease ICR & if <25 above pre-meal value, increase ICR by 1-2 gm for that meal. (3-4 hr PP for regular insulin)
- Patient must eat low fat meal of known carb content. Avoid periods of unusual activity & stress.

CALCULATE INSULIN SENSITIVITY FACTOR (ISF)

- Insulin Sensitivity Factor refers to mg% drop in BG expected with 1 U bolus insulin
- ISF (formula): $ISF = \frac{1800}{TDD}$
- Fine tune using pre and 2 / 4 hours post-meal BG
- Never adjust ICR and ISF concurrently.

FINE TUNE ISF

- ISF is correct if 2-hr post correction BG is halfway to goal & is at goal by 4 hours. (or is within 30 mg% of target at 2 hrs)
- Decrease ISF by 10-20% if values are > target BG; increase by 10-20% if < target.
- Evaluate ISF when no insulin given or food eaten for ≥ 3 hours. Avoid eating for 4 hrs till evaluation is over.
- *If correction boluses are needed often, revise ICR or basal rate.*

CALCULATE PRE-MEAL INSULIN BOLUS

1. Dose needed to cover carb content of meal (1CR)
- +
2. Dose needed for pre-meal BG if outside target range (ISF)
- 3. *For anticipated post meal activity. (if expected to be high within 2-3 hrs reduce bolus)*
- 4. *Active insulin.*

Acta Diabetol. 2015 Feb 20.

Glycemic load versus carbohydrate counting for insulin bolus calculation in patients with type 1 diabetes on insulin pump.

Bozzetto L, Giorgini M, Alderisio A, Costagliola L, Giacco A, Riccardi G, Rivellese AA, Annuzzi G

- 9 patients with T1DM on CSII, 26-58 yrs, randomized to calculate insulin dose based on insulin/GLC ratio or ICR for 1 week.
- **CONCLUSION:** Calculating prandial insulin bolus based on GLC is feasible in a real-life setting and may improve PP BG control in T1DM.

CONCEPT OF FoodInsulinIndex

- Besides GI /GL, carb counting also does not take in account, protein or fat content; but, stimulation of insulin release is multifactorial.
- FII measures increase in insulin level in response to whole food; (1000Kj or 240kcal portions of single foods in normal adults);
- (Beef & chicken, have zero carbs, but FIIs of 37 & 19, resp).

FII

- FII is more accurate predictor of observed insulin response in healthy subjects than carb content (*Am J Clin Nutr.* 2009;90:986-992).
- FII algorithm significantly decreased PP BG following 2 different breakfast meals in 28 patients with T1DM on CSII (*Diabetes Care.* 2011;34:2146-2151).

FatProteinUnit: PRACTICAL APPLICATION

- 1 FPU equal 100 kcals of fat or protein. It requires the same amount of insulin (as extended SQ-W bolus) as 10 grams of carbs
- The time length of a SQ-W bolus should be 3,4,5 or 8 hours for meals having 1,2,3 or > 3 FPU resp.

Benefit of supplementary fat plus protein counting as compared with conventional carbohydrate counting for insulin bolus calculation in children with pump therapy.

[Kordonouri O](#), [Hartmann R](#), [Remus K](#), [Bläsing S](#), [Sadeghian E](#), [Danne T](#).

[Pediatr Diabetes](#). 2012 Nov;13(7):540-4.

- 42 T1DM youth on CSII.
- Given standardized meals at lunch on 4 days with normal & dual-wave bolus using carb & CFP counting in randomized sequence.
- CGMS of 6-h PP BG profiles.
- AUC mg/dL × 6 h; & AV BG significantly lower using CFP than carb counting.
- PP hypoglycemia more frequent with CFP than carb counting (no severe hypoglycemia)

4. PREVENTION OF HYPOGLYCEMIA

- Consistency in timing & carb intake, frequent small meals, snack at time of peak insulin action OR correct application of carb counting.
- Carry snacks to school / while on journey.
- Glucose powder / powdered sugar in pocket; with diabetic ID card.
- Exercise planning.....

EXERCISE PLANNING



- For anticipated activity: insulin dose reduction & avoid inj. in exercising limb.
- For unanticipated activity: extra snack.
- Steps for prevention of post exercise delayed (nocturnal) hypo

ADDITIONAL SNACK FOR UNANTICIPATED ACTIVITY

DURATION	BG	AMT OF CARB
Short (<30 min)	<100	15 gm
	>100	Nil needed
Moderate (30min-1 hr)	<100	25-50 gm + protein
	100-180	15 gm
	180-240	Nil needed
Long (1-2 hrs)	<100	50 gm + protein
	100-180	15 gm
	180-240	Nil needed

PRE-EXERCISE: MEAL PRECAUTIONS

- For exercise within 1 hr of meal → extra snack may be unnecessary
- Liquids (milk, juices) are rapidly absorbed, prevent hypo for 30-60 min.
- Solid foods digested slowly, protect for ≥ 2 hrs. (give along with the liquids for prolonged activity).

NOCTURNAL HYPOGLYCEMIA: PREVENTION

- Bedtime snack of low GI carb. Add protein if sufficient carb is already being taken.
- Uncooked cornstarch: mix 2 tbsf of corn flour in 100 ml (half cup) water (=14 gm of slow acting carb); stir to mix. Mix cold & heat as little as possible; to prevent breaking the cell wall which would make cornstarch easier to absorb. 0.3 gm/kg raises BG at 2 am by 35 mg%.
- Monitor bedtime & 3 am BG (esp. after evening activity) : extra snack if bedtime BG <100.
- Change of insulins (human to analogues)

TREATMENT OF HYPOGLYCEMIA

1. When BG is <70 mg%: 10-15 gm of fast acting carb (sugar or glucose 3 tsf / fruit juice 4 oz / non-diet soft drink 6 oz / honey 1 tbsf). If BG <50 : 20-30 gm.
 2. Retest after 15 minutes & re-treat if necessary till BG > 70 mg%
 3. Now have a snack = 15 gm carb if next regular meal is not due early.
- Never over treat a hypo.

SICK DAY GUIDELINES

- Never omit insulin (unless BG < 80; with ketones & anorexia).
- Follow BG & ketones, not the appetite
- May need insulin supplements: if BG > 200 mg% with ketonuria.
- Plenty of liquids: cool, of child's choice & in small frequent sips.
- Salty liquids when BG > 150 mg%; Sweet liquids if BG < 150 mg%.
- Hospitalize if > 3 vomits; drowsy; breathless; needs > 3 supplements of insulin.