Nutrition and metabolism in burn patients

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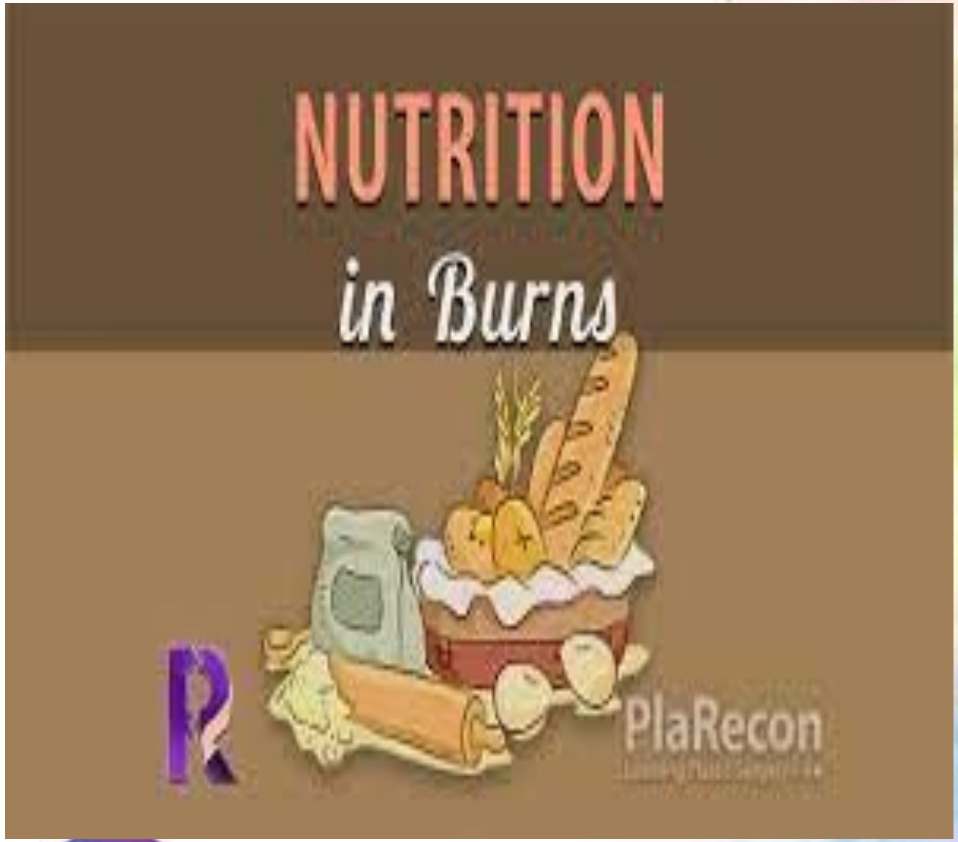
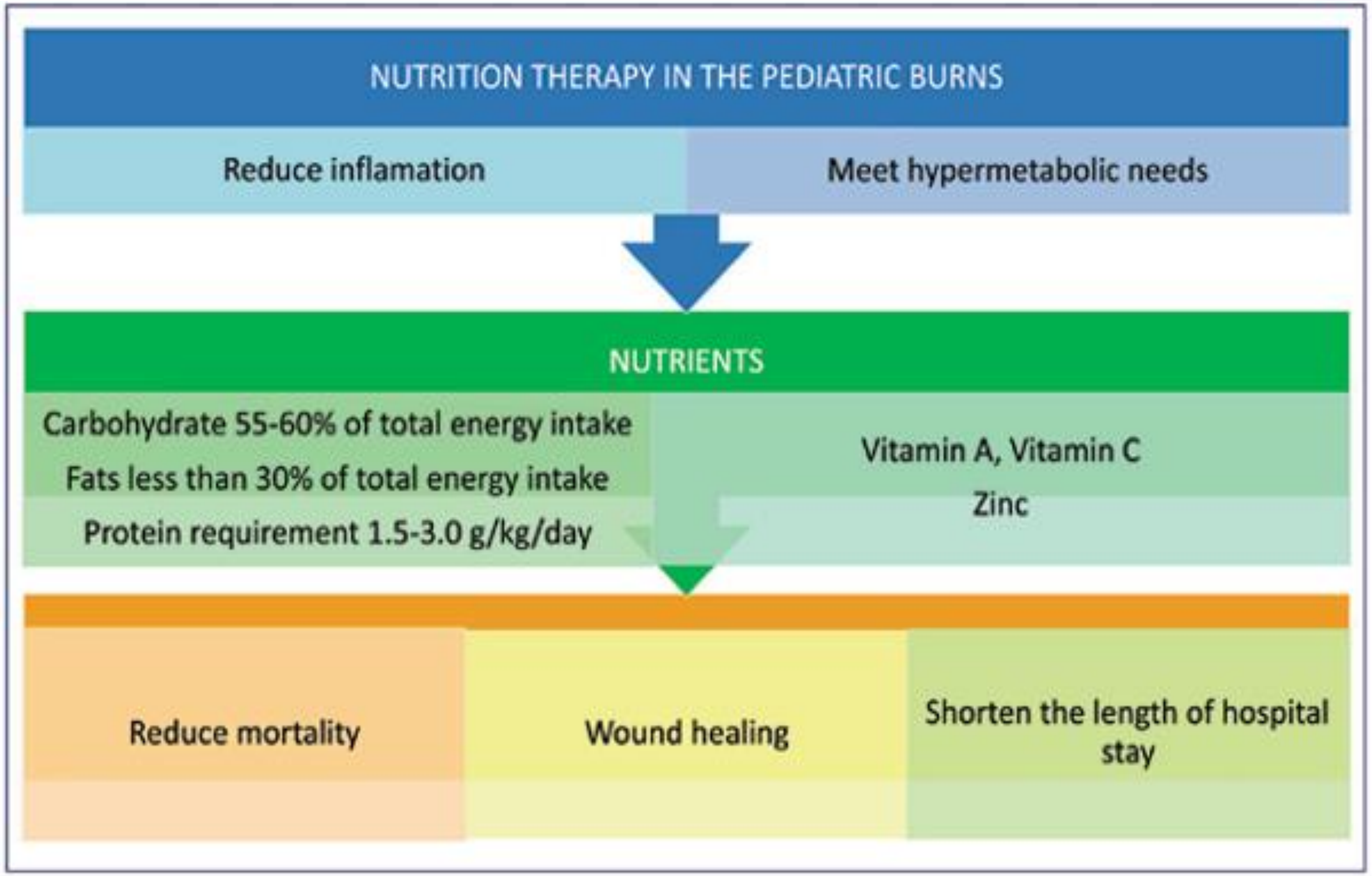
Introduction

- Burn injury causes a persistent and prolonged hypermetabolic state and increased catabolism that results in increased muscle wasting and cachexia.
- Metabolic rates of burn patients can surpass twice normal, and failure to fulfill these energy requirements causes impaired wound healing, organ dysfunction, and susceptibility to infection.

- Adequate assessment and provision of nutritional needs is imperative to care for these patients.
- There is no consensus regarding the optimal timing, route, amount, and composition of nutritional support for burn patients, but most clinicians advocate for early enteral nutrition with high-carbohydrate formulas.

- Nutritional support must be individualized, monitored, and adjusted throughout recovery.
- Further investigation is needed regarding optimal nutritional support and accurate nutritional endpoints and goals.

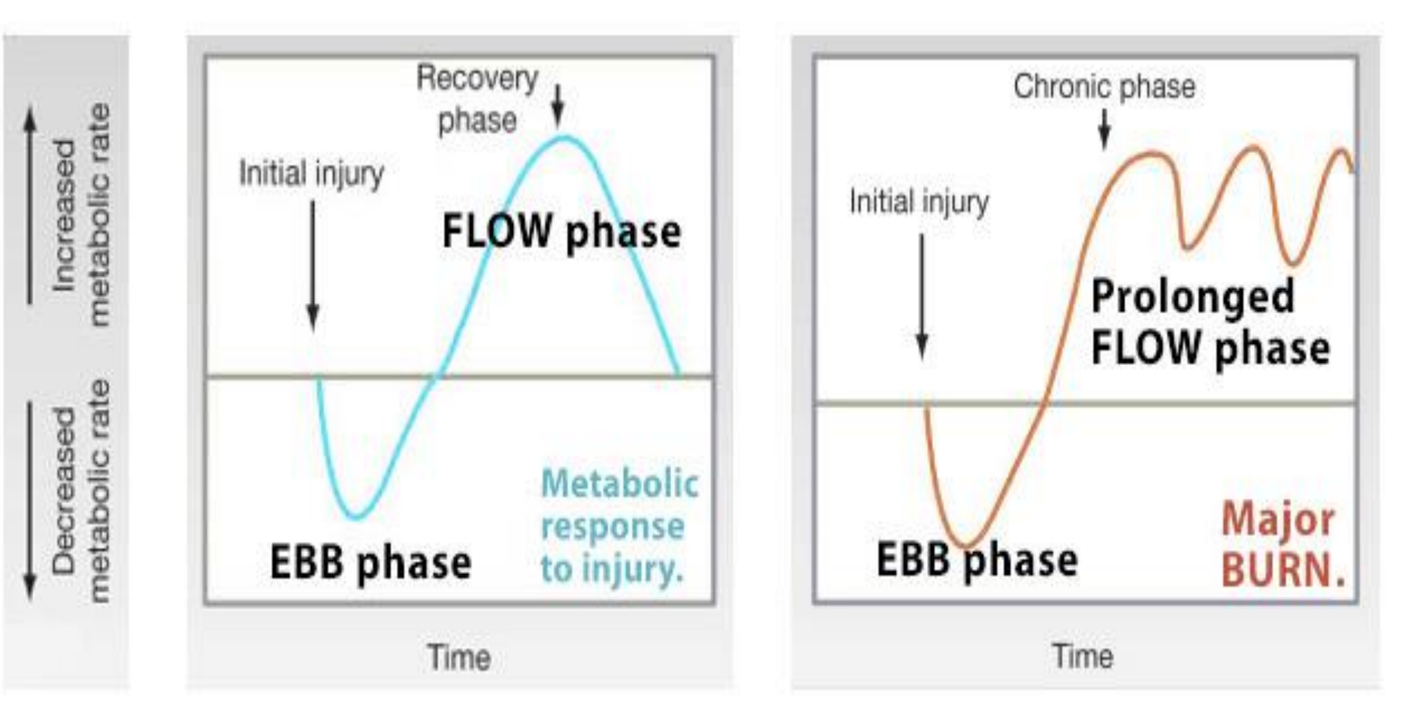




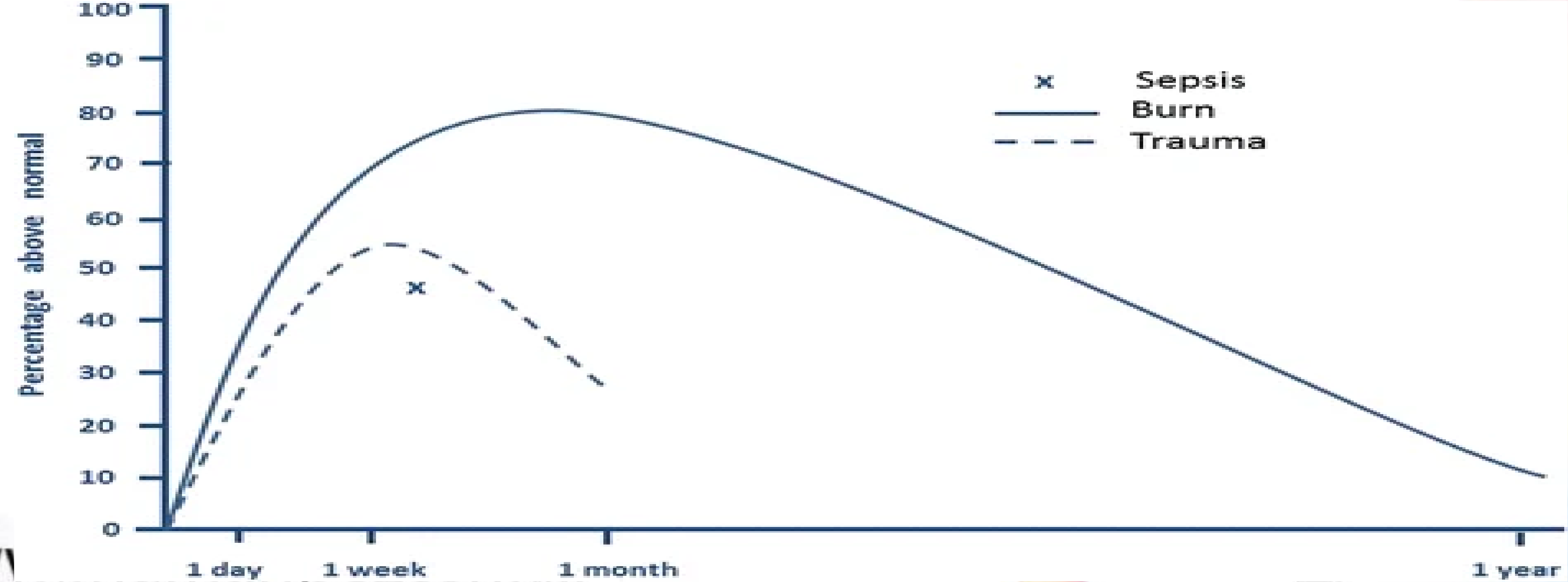
Nutrition therapy in pediatric burns.

The hypermetabolic state

Immediately after severe injury, patients have a period of decreased metabolism and reduced tissue perfusion known as the “ebb” phase. Soon after, they enter the phase of hypermetabolic rates and hyperdynamic circulation, referred to as the “flow” state



Hypermetabolic response after severe burn, trauma, and sepsis.



- Burn patients are in a catabolic state that can lead to significant weight loss and associated complications.
- A 10% loss of total body mass leads to immune dysfunction, 20% to impaired wound healing, 30% to severe infections, and 40% to mortality.
- Early enteral feeding does result in improved muscle mass maintenance, the modulation of stress hormone levels, improved gut mucosal integrity, improved wound healing, decreased risk of Curling ulcer formation, and shorter intensive care unit stay and is therefore universally recommended despite its link to the hypermetabolic state.

Timing of nutritional support

- Time to treatment, including time to nutrition, is an important factor for patient outcome after severe burn.
- Substantial intestinal mucosal damage and increased bacterial translocation occur after burn and result in decreased absorption of nutrients

- Because of this, nutritional support should ideally be initiated within 24 h of injury via an enteral route

- Early enteral feeding in humans has also shown to result in improved muscle mass maintenance, improved wound healing, decreased risk of Curling ulcer formation, and shorter intensive care unit stay

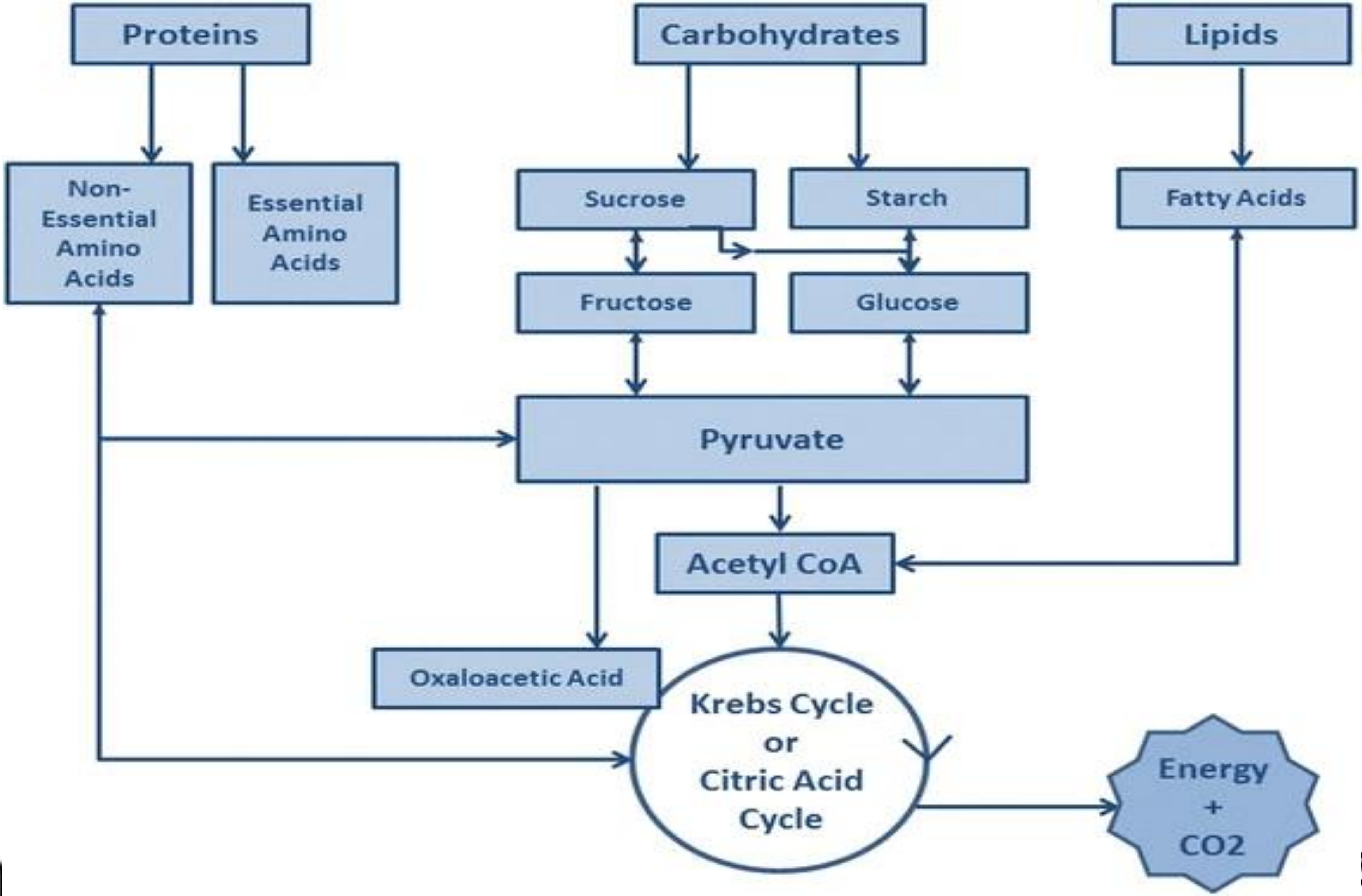
- Nutrition, both parenteral and enteral, is almost always administered in a continuous fashion. For parenteral nutrition (PN), this is done for logistical reasons, but reasons for continuous feeding are less clear for EN. At the start, enteral feeding is initiated in a continuous and low volume manner with slow titration to the goal volume to insure that the patient can tolerate this regimen.

- A continuous schedule is usually continued even when the patient is having no issues with tolerance.
- Continuous enteral feeding is likely a holdover from parenteral schedules and no data have shown the superiority of either schedule, but the data are limited.

Caloric requirements

- The primary goal of nutritional support in burn patients is to fulfill the increased caloric requirements caused by the hypermetabolic state while avoiding overfeeding.
- Numerous formulas to estimate the caloric needs of burn victims have been developed and used throughout the years.

- Indirect calorimetry (IC) is the current gold standard for the measurement of energy expenditure, but it is not practical to perform on a routine basis.
- IC machines measure the volume of expired gas and the inhaled and exhaled concentrations of oxygen and carbon dioxide via tight-fitting face masks or ventilators, allowing for the calculation of oxygen consumption (VO_2) and carbon dioxide production (VCO_2), and therefore metabolic rate.


Proteins
Carbohydrates
Lipids
Non-Essential Amino Acids
Essential Amino Acids
Sucrose
Starch
Fatty Acids
Fructose
Glucose
Pyruvate
Acetyl CoA
Oxaloacetic Acid
Krebs Cycle or Citric Acid Cycle
Energy + CO2

Carbohydrates

- Carbohydrates are the favored energy source for burn patients as high-carbohydrate diets promote wound healing and impart a protein-sparing effect.
- carbohydrates an extremely important part of the burn patient’s diet; however, there is a maximum rate at which glucose can be oxidized and used in severely burned patients (7 g/kg/day) .
- This rate can be less than the caloric amount needed to prevent lean body mass loss, meaning severely burned patients may have greater glucose needs than can be safely given.
- If glucose is given in excess of what can be utilized, it leads to hyperglycemia, the conversion of glucose to fat, glucosuria, dehydration, and respiratory problems

- The hormonal environment of stress and acute injury causes some level of insulin resistance, and many patients benefit from supplemental insulin to maintain satisfactory blood sugars. Insulin therapy also promotes muscle protein synthesis and wound healing.
- severely burned patients who received insulin infusions, in conjunction with a high-carbohydrate, high-protein diet, have improved donor site healing, lean body mass, bone mineral density, and decreased length of stay .
- Hypoglycemia is a serious side effect of insulin therapy, and patients must be monitored closely to avoid this complication.

Fat

- Fat is a required nutrient to prevent essential fatty acid deficiency, but it is recommended only in limited amounts .
- After burn, lipolysis is suppressed and the utilization of lipids for energy is decreased.
- The increased beta-oxidation of fat provides fuel during the hypermetabolic state; however, only 30% of the free fatty acids are degraded and the rest go through reesterification and accumulate in the liver.
- very low-fat diets (<15% of total calories) in burn patients where no more than 15% of total calories come from lipids.
- Multiple low-fat enteral formulas have been created for this purpose, and for patients receiving short-term (<10 days) PN, many clinicians forego lipid emulsions.

- The most commonly used formulas contain omega-6 fatty acids such as linoleic acid, which are processed via the synthesis of arachidonic acid, a precursor of proinflammatory cytokines (e.g., prostaglandin E_2).
- Lipids that contain a high percentage of omega-3 fatty acids are metabolized without promoting proinflammatory molecules and have been linked to enhanced immune response, reduced hyperglycemia, and improved outcomes.

Protein

- Proteolysis is greatly increased after severe burn and can exceed a half pound of skeletal muscle daily.
- Protein supplementation is needed to meet ongoing demands and supply substrate for wound healing, immune function, and to minimize the loss of lean body mass.
- Protein is used as an energy source when calories are limited; however, the opposite is not true. Giving excess calories will not lead to increased protein synthesis or retention, but rather lead to overfeeding.

- Currently, protein requirements are estimated as 1.5–2.0 g/kg/day for burned adults and 2.5–4.0 g/kg/day for burned children.
- Non-protein calorie to nitrogen ratio should be maintained between 150:1 for smaller burns and 100:1 for larger burns .
- Even at these high rates of replacement, most burn patients will experience some loss of muscle protein due to the hormonal and proinflammatory response to burn injury.

- Glutamine is rapidly exhausted from muscle and serum after burn injury, and administration of 25 g/kg/day of glutamine has been found to reduce mortality and length of hospitalization in burn patients .
- Arginine is another important amino acid because it stimulates T lymphocytes, augments natural killer cell performance, and accelerates nitric oxide synthesis, which improves resistance to infection .
- The supplementation of arginine in burn patients has led to improvement in wound healing and immune responsiveness

Vitamins and trace elements

- The metabolism of numerous “micronutrients” (vitamins and trace elements) is beneficial after burn as they are important in immunity and wound healing.
- Severe burn leads to an intense oxidative stress, which combined with the substantial inflammatory response, adds to the depletion of the endogenous antioxidant defenses, which are highly dependent on micronutrients .
- Decreased levels of vitamins A, C, and D and Fe, Cu, Se, and Zn have been found to negatively impact wound healing and skeletal and immune function .
- Vitamin A decreases time of wound healing via increased epithelial growth, and vitamin C aids collagen creation and cross-linking

- The trace elements Fe, Cu, Se, and Zn are important for cellular and humoral immunity, but they are lost in large quantities with the exudative burn wound losses .
- Zn is critical for wound healing, lymphocyte function, DNA replication, and protein synthesis .
- Fe acts as a cofactor for oxygen-carrying proteins, and Se boosts cell-mediated immunity .
- Cu is crucial for wound healing and collagen synthesis, and Cu deficiency has been implicated in arrhythmias, decreased immunity, and worse outcomes after burn. Replacement of these micronutrients has been shown to improve the morbidity of severely burned patients

Routes of nutrition: parenteral vs. enteral

- PN was routinely used for burn patients in the 1960s and 1970s, but it has been almost completely replaced by EN
- Studies found that PN, alone or in conjunction with EN, is associated with overfeeding, liver dysfunction, decreased immune response, and three-fold increased mortality .
- PN also appears to increase the secretion of proinflammatory mediators, including TNF, and also can aggravate fatty infiltration of the liver .
- In addition to these issues, PN has more mechanical and infectious complications of catheters, and PN solutions are significantly more expensive than EN formulas.

- EN decreases hyperglycemia and hyperosmolarity as it has a “first-pass” hepatic delivery of nutrients .
- For all of these reasons, EN is the route of choice for severely burned patients.
- EN can be administered as either gastric or post-pyloric feedings, and both are widely used. Gastric feeding has the advantages of larger diameter tubes, which have less clogging and the ability to give bolus feeds; however, the stomach often develops ileus in the postburn state.

- Despite the strong preference to give nutritional support primarily via the gastrointestinal tract, PN can be used in burned patients in whom EN is contraindicated.
- Further research is warranted regarding if parenteral supplementation of specific dietary components, such as amino acids alone, would be beneficial.
- PN and EN are usually given in a continuous fashion.

Formulas

- The earliest formulas for burn patients consisted of milk and eggs, and although these simple mixtures were relatively successful at providing adequate nutrition, they were very high in fat.
- Numerous commercially prepared enteral formulas have been developed since that time, all with differing amounts of carbohydrates, protein, fats, and micronutrients .
- Glucose is the preferred energy source for burn patients and they should therefore be administered a high-carbohydrate diet .
- Parenteral formulas usually consist of 25% dextrose, 5% crystalline amino acids, and maintenance electrolytes.
- This is often supplemented with infusions of 250 mL of 20% lipid emulsions three times a week to meet essential fatty acid needs

ترکیبات:

• 7 گرم ال-گلوتامین
• 7 گرم ال-آرژنین
• 1/5 گرم بتاهیدروکسی بتامتیل بوتیرات

گلوتامین

- افزایش نیاز به دنبال استرس های فیزیولوژیک مانند جراحی و سپسیس
- منبع اصلی انرژی (به جای گلوکز) برای رونویسی DNAو RNAقبل از میتوز در سلول های اصلی در سیستم ایمنی (

•آرژنین

- کاهش تجمع کلاژن و استحکام زخم در محل جراحت به دنبال سطوح پایین آرژنین
- نقش در سنتز کلاژن با افزایش تولید اورنیتین (پیش ساز پرولین) توسط آرژیناز
- افزایش هیدروکسی پرولین در محل زخم، افزایش عملکرد لنفوسیت Tو تعادل مثبت نیتروژن
- افزایش سطح NOدر محل جراحت به عنوان یک آنتی اکسیدان قوی و کاهش استرس اکسیداتیو

بتاهیدروکسی بتامتیل بوتیرات ((HMB

- جلوگیری از پروتئولیز ماهیچه ها
- کاهش دفع ادراری 3- متیل هیستیدین
- فعال شدن سنتز پروتئین
- افزایش بیان فاکتور شبه انسولین ((IGFI

ترکیبات:

- حاوی ۱۰۰ ٪ پروتئین وی ایزوله خالص
- گلوتامین (1/5 گرم در هر ساشه)
- فاقد گلوتن
- کم لاکتوز

ترکیبات:

- 12/8% انرژی از پروتئین آب پنیر و شیر
- 50/2% انرژی از کربوهیدرات های ساده و پیچیده
- 37% انرژی از چربی از منبع روغن نارگیل و آفتابگردان
- فیبر اینولین با خاصیت پره بیوتیکی جهت افزایش مقاومت بدن و بهبود حرکات روده
- فیبر جو دوسر
- کارنیتین، تورین و میواینوزیتول
- کلیه ویتامین ها و املاح ضروری
- فاقد گلوتن و کم لاکتوز
- مجموعه آنزیمی

کالری میل یک مکمل پودری با دانسیته کالری بالا، بلع آسان و طعم مطلوب می باشد که به منظور فراهم نمودن انرژی لازم برای رفع تعادل منفی انرژی و بهبود کیفیت زندگی استفاده می شود.

کالری میل دارای غلظت بالایی بوده و نمی توان از آن به عنوان فرمولای آماده گاواژ استفاده کرد.

ترکیبات:

- 7% انرژی از پروتئین با ارزش بیولوژیکی بالا (Whey) و شیر
- 43% انرژی از چربی از منبع روغن کانولا، آفتابگردان و نارگیل (منبع MCT)
- 50% انرژی از کربوهیدرات ساده و پیچیده
- حاوی اینولین
- فاقد گلوتن
- کم لاکتوز

Nutrition Facts
Serving Size: 1 Sachet (92 g)

	Amount Per Sachet	% Daily Value*	Amount Per Solution (milk 3% fat)
Calorie	452		596
Total Carbohydrate (g)	58	19	70
Dietary Fiber (g)	4.6	18.4	4.6
Sugar (g)	17	†	28.9
Fat (g)	22	34	29
Protein (g)	7.8	15	15.4
Sodium (mg)	86.1	3.6	189
Potassium (mg)	142	4	459
Magnesium (mg)	7.4	2	31.4
Calcium (mg)	147.7	14.8	419
Phosphorus (mg)	337	33.7	538

* Percent daily values are based on a 2000 calorie diet.
† Daily Value not established.

Monitoring of nutritional support

- It is challenging to objectively assess the success of nutritional support of a burn patient, as the true endpoint of therapy is global and cannot be measured by one variable.
- The overall goal of therapy is to reestablish normal body composition and metabolic equilibrium, and commonly measured variables include body weight, nitrogen balance, imaging of lean body mass, and measurement of serum proteins. Functional measures such as exercise tolerance have also been proposed as a possible metric.

- Nitrogen balance for burn patients can be approximated with the following formula:

- Nitrogen balance=Nitrogen intake in 24 h --[1.25×(UUN+4)]
- Errors in the calculation can come from the two constants. To approximate total urinary nitrogen, 4 g/dL is added to UUN, but total urinary nitrogen may surpass this value in burn patients, leading to an underestimation of nitrogen loss [118, 119]. To account for substantial loss of protein-rich exudates from burn wounds, estimated total urinary nitrogen is multiplied by 1.25, which can similarly underestimate nitrogen losses.

Overfeeding

- The estimation of the nutritional needs of burn patients can be very difficult, and aggressive nutrition in the early post-injury stage can lead to inadvertent overfeeding as the metabolic rate slows and intestinal absorption improves.
- Overfeeding carries numerous complications, including difficulty weaning from ventilatory support, fatty liver, azotemia, and hyperglycemia. Overfeeding of carbohydrates leads to fat synthesis, increased carbon dioxide, and an increase in the RQ, which worsens respiratory status and makes liberation from the ventilator more challenging

- Resistance exercise is also recommended to combat continued loss of muscle mass. Patients should regularly weigh themselves to ensure they are maintaining their weight as instructed by the physician and dietician.
- Oxandrolone is often continued in the outpatient setting, but no data exist regarding the optimum duration of therapy and further study is needed. Nutritional assessments should be a consistent component of outpatient follow-up for burn patients.

Nutrition after discharge

- It is important that patients continue to receive adequate nutrition after discharge from the hospital, but data on the optimal diet after the acute postburn phase are virtually nonexistent.
- Because the hypermetabolic state can persist for over a year after burn injury, increased caloric intake with a high protein component is usually recommended for about a year after discharge.

Any Question?