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# New Trends in Nutritional Support of Critically Ill Patients

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# Introduction

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Nutritional support refers to enteral or parenteral delivery of carbohydrates, proteins, electrolytes, vitamins, minerals, trace elements and fluids to the critically ill patients, the fundamentals of nutritional support for critically ill patients have been the subject of clinical practice guidelines ***(McClave et al., 2009).***

Upon admission to hospital, about 15–70% of patients are under or malnourished ***(Neelemaat et al., 2008).***

It has been reported that malnutrition remains undiagnosed in up to 70% of patients admitted to hospital and about 70-80% of the admitted malnourished patients enter and leave the hospital without receiving any nutritional support and the diagnosis of malnutrition does not appear on their discharge sheet ***(Lean and Wiseman, 2008).***

Underfeeding is associated with weakness, infection, and increased duration of mechanical ventilation, and death ***(Alberda et al., 2009).***

The early initiation of parenteral nutrition to supplement the insufficient enteral nutrition during the first week after ICU admission in severely ill patients at risk for malnutrition appears to be inferior to the strategy of withholding parenteral nutrition until day 8 while providing vitamins, trace elements, and minerals, late parenteral nutrition was associated with fewer infections, enhanced recovery, and lower health care costs ***(Casaer et al., 2011).***

The increased rates of infection and delayed recovery from organ failure that are associated with the early administration of parenteral nutrition may be explained by a suppression of autophagy, with inadequate clearance of cell damage and microorganisms ***(Vanhorebeek et al., 2011).***

Enteral plus parenteral supply of immunonutrient glutamine has more beneficial effects on transferrin and creatine/height index than only enteral or parenteral supply, also we observed that enteral feeding of glutamine has beneficial effects on feeding parameters (transferrin, nitrogen balance and creatine/height index) for malnutrition in septic patients ***(Koksal et al., 2011)***.

Immunonutrition with a formula enriched with omega-3 fatty acids, γ-linoleic acid, and antioxidants has been shown to reduce ventilator requirements, length of ICU stay, and the incidence of organ failure in patients with acute lung injury or acute respiratory distress syndrome and, more recently, to reduce mortality rates in mechanically ventilated patients with severe sepsis and septic shock ***(Pontes et al., 2006).***

# Chapter I: Physiology of Nutrition

# Physiology of nutrition

Nutrition is the organic process of nourishing or being nourished and the processes by which an organism assimilates food and uses it for growth and maintenance. Nutrients are substances that are essential to life, which must be supplied by food. There are six nutrients which are required by the human body, they are carbohydrates, fats, proteins, vitamins, minerals and water ***(Swaminathan, 2002).***

## Carbohydrates :

**Carbohydrates recommended dietary allowance (RDA):** At least 55% of total calories should be derived from carbohydrates. The brain requires about 100 g/d of glucose for fuel; other tissues use about 50 g/day. Over time adaptations in carbohydrate needs are possible in hypocaloric states, for example reduced insulin levels lead to adipose tissue breakdown and cause the body to burn more fatty acids. However, some tissues (e.g., brain and red blood cells) rely on glucose for fuel which is supplied either exogenously or from muscle proteolysis ***(Johanna, 2005).***

**Digestion of carbohydrates:** Dietary carbohydrates consist of mainly plant and animal starches, polysaccharides, disaccharides such as sucrose and lactose, and monosaccharides such as glucose and fructose. Dietary monosaccharides (glucose, fructose, and galactose) require no further digestion to be absorbed from the gastrointestinal tract. Dietary disaccharides such as lactose and sucrose are hydrolyzed to monosaccharides such as glucose and fructose by a series of specific disaccharidases, which are attached to the small intestinal brush border membrane. The digestion of polysaccharides is carried out by endosaccharidases and amylase produced by the salivary glands and pancreas. The products of hydrolysis of starch are the disaccharide maltose;

these products are then further hydrolyzed by the α-glucosidases enzymes bound to the enterocyte mucosal membrane to form the monosaccharide glucose. **Absorption of carbohydrates:** There are active and passive transport systems which transport carbohydrates across the brush border membrane. Glucose, fructose, and galactose are the primary monosaccharides produced by the digestion of dietary carbohydrates; the absorption of these sugars and other monosaccharides is via specific carrier-mediated mechanisms. In addition all monosaccharides can cross the brush border membrane by a simple diffusion process, although this is extremely slow. At the brush border membrane both glucose and galactose are transported by the $Na^+$ dependent glucose transporter and $Na^+$ dependent ATPase , which removes $Na^+$ from the cell in exchange for $K^+$, with the concomitant hydrolysis of (ATP). The transport of glucose is thus an indirect active process. Fructose is transported across the brush border membrane by $Na^+$ independent facilitated diffusion process by a specific membrane associated protein called glucose transporter (GLUT-5) which is present on the luminal side of the enterocyte and (GLUT-2) which is present on the antiluminal side ***(Baynes and Dominiczak, 2007).***

**Carbohydrates metabolism:** Glucose is the major fuel of most tissues; it is metabolized to pyruvate by the pathway of glycolysis. **The glycolysis:** It is aerobic tissues metabolism of pyruvate to acetyl CoA, which can enter the citric acid cycle for complete oxidation to $CO_2$ and $H_2O$, glycolysis can also occur anaerobically (in the absence of oxygen) and the end product is lactate. **Citric acid cycle:** the major catabolic pathway for acetyl CoA in aerobic organisms. Acetyl CoA the product of carbohydrate, protein, and lipid catabolism, is taken into the cycle and oxidized to $CO_2$ with the release of reducing equivalents (2H) with subsequent oxidation of 2H in the respiratory chain leads to phosphorylation of ADP to ATP. The citric acid cycle is not only a pathway for oxidation of two carbon units, but is also a major pathway for

interconversion of metabolites arising from transamination and deamination of amino acids and providing the substrates for amino acid synthesis by transamination, as well as for gluconeogenesis and fatty acid synthesis so that the citric acid cycle is amphibolic because it functions in both oxidative and synthetic processes. Glucose and its metabolites also take part in other processes e.g.: (1) Synthesis of the storage polymer glycogen in skeletal muscle and liver. (2) The pentose phosphate pathway. It is a source of reducing equivalents (NADPH) for fatty acid synthesis and the source of ribose for nucleotide and nucleic acid synthesis. (3) Triose phosphates give rise to the glycerol moiety of triacylglycerols. (4) Pyruvate and intermediates of the citric acid cycle provide the carbon skeletons for the synthesis of amino acids and acetyl CoA is the precursor of fatty acids and cholesterol (and hence of all steroids synthesized in the body). **Gluconeogenesis:** It is the process of forming glucose from noncarbohydrate precursors, e.g., lactate, amino acids, and glycerol ***(Briere et al., 2006).***

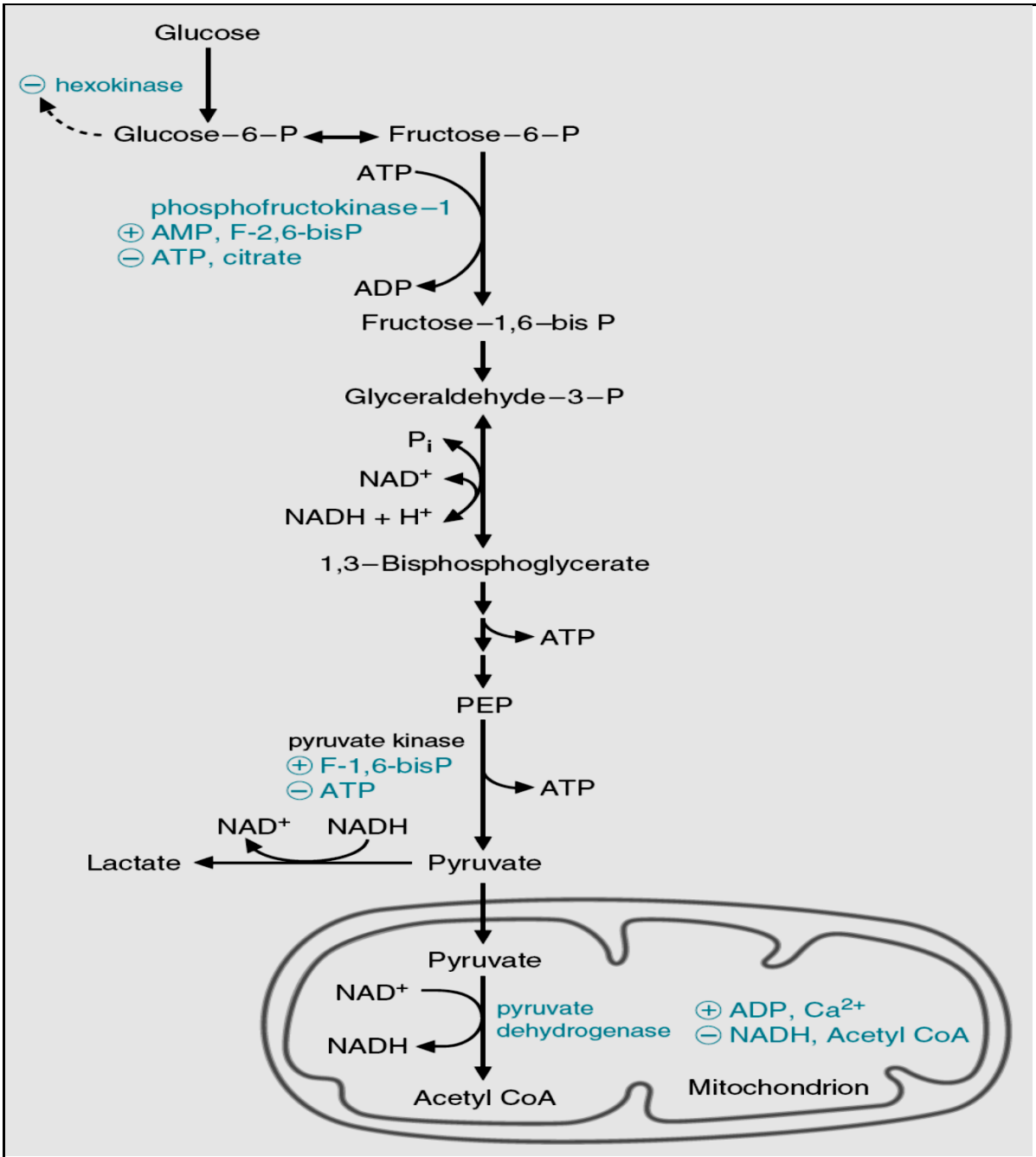


**Figure (1): Summary of Glycolysis:** The glycolysis occurs in the **cytosol** and begins with the phosphorylation of glucose to glucose 6-phosphate (**glucose-6-P**) by **hexokinase.** In subsequent steps of the pathway, one glucose-6-P molecule is oxidized to two **pyruvate** molecules with generation of two molecules of **NADH**. A net generation of two molecules of ATP occurs through direct transfer of **high-energy phosphate** from intermediates of the pathway to **ADP** (**substrate level phosphorylation**). Pyruvate is then oxidized completely to $CO_2$ by pyruvate dehydrogenase and the TCA cycle. Complete **aerobic oxidation** of glucose to $CO_2$ can generate approximately **30 to 32 moles of ATP per mole of glucose**. **Hexokinase and phosphofructokinase-1** are the major regulatory enzymes of **glycolysis** in skeletal muscle. The activity of pyruvate dehydrogenase in the mitochondrion determines whether pyruvate is converted to lactate or to acetyl CoA.

***(Colleen et al., 2004).***

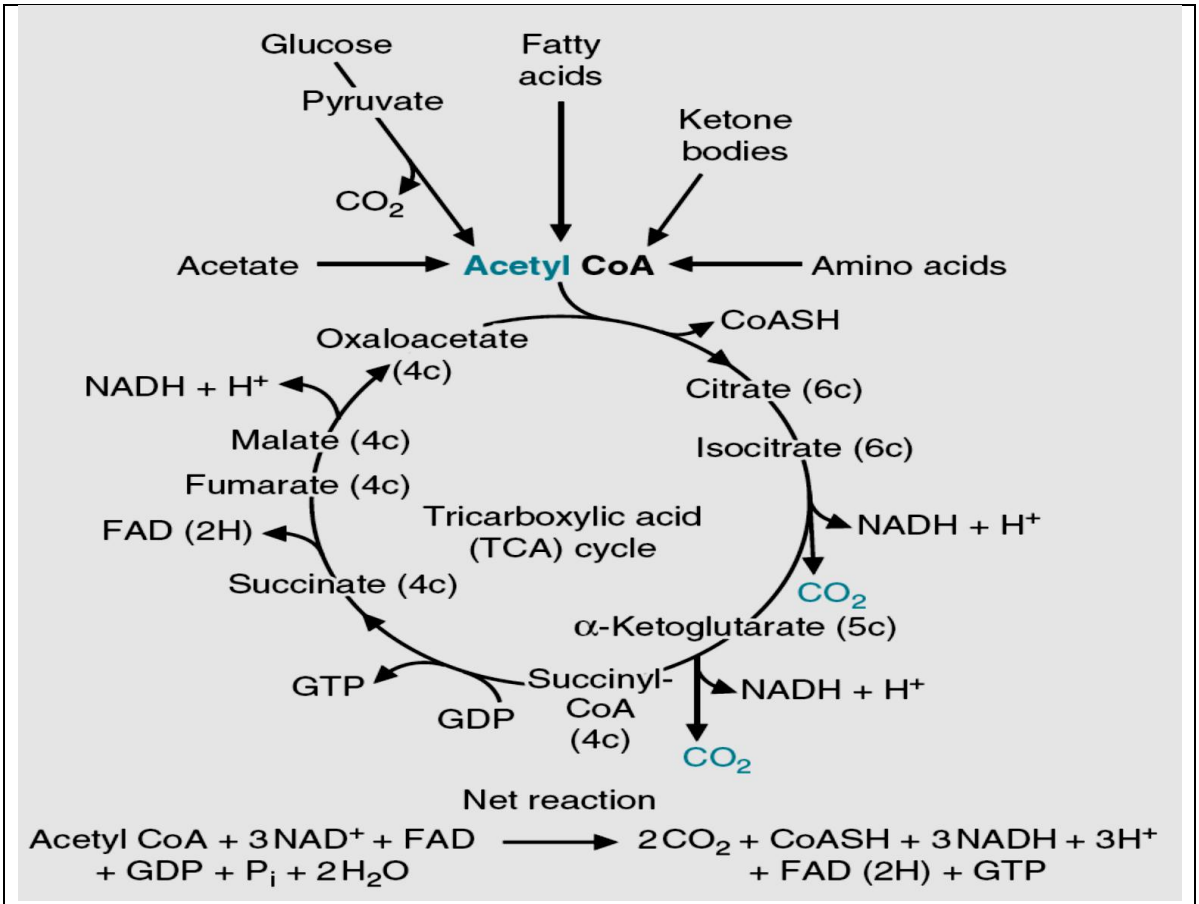


**Figure (2): Summary of TCA cycle:** The TCA cycle (tricarboxylic acid cycle) accounts for over two thirds of the ATP generated from fuel oxidation. The pathways for oxidation of fatty acids, glucose, amino acids, acetate, and ketone bodies all generate **acetyl CoA,** which is the substrate for the TCA cycle. As the activated 2-carbon acetyl group is oxidized to two molecules of **$CO_2$**, energy is conserved as **NADH, FAD (2H),** and **GTP**. NADH and FAD (2H) subsequently donate electrons to $O_2$ via the electron transport chain, with the generation of ATP from oxidative phosphorylation. Thus the TCA cycle is central to energy generation from **cellular respiration.** Within the TCA cycle, the oxidative decarboxylation of α-ketoglutarate is catalyzed by the **α-ketoglutarate dehydrogenase complex,** which contains the coenzymes **thiamine-pyrophosphate, lipoate,** and **FAD.** A similar complex, the **pyruvate dehydrogenase complex (PDC),** catalyzes the oxidation of pyruvate to acetyl CoA, thereby providing a link between the pathways of glycolysis and the TCA cycle. The two-carbon acetyl group is the ultimate source of the electrons that are transferred to $NAD^+$ and FAD and also the carbon in the two $CO_2$ molecules that are produced. Oxaloacetate is used and regenerated in each turn of the cycle. However, when cells use intermediates of the TCA cycle for biosynthetic reactions, the carbons of oxaloacetate must be replaced by **pyruvate carboxylase reaction.** The TCA cycle occurs in the mitochondrion, where its flux is tightly coordinated with the rate of the electron transport chain and oxidative phosphorylation through **feedback regulation that reflects the demand for ATP.**

***(Colleen et al., 2004).***

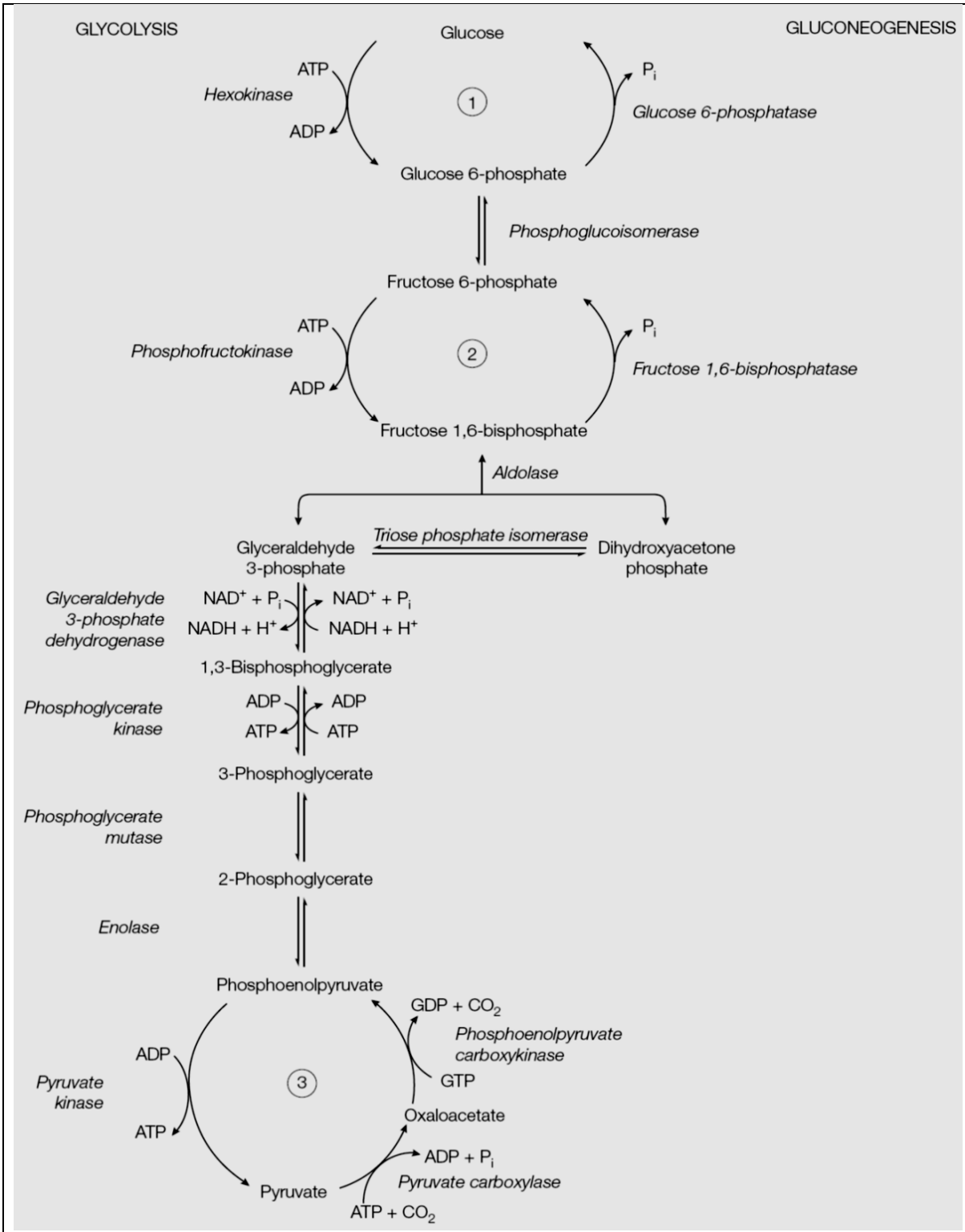


**Figure (3): Summary of gluconeogenesis:** The gluconeogenesis is a reversal of glycolysis e.g., some of the reactions of glycolysis are reversible and there are three steps are irreversible are (1) Hexokinase in glycolysis is reversed by glucose 6-phosphatase in gluconeogenesis; (2) Phosphofructokinase in glycolysis is reversed by fructose 1, 6 bisphosphatase in gluconeogenesis; (3) Pyruvate kinase in glycolysis is reversed by two sequential reactions in gluconeogenesis catalyzed by pyruvate carboxylase and phosphoenolpyrovate carboxykinase.

***(Hames and Hooper, 2000).***