13C-Leucine-Tracer-Technique in clinical research on postoperative protein metabolism

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Abstract

The non-invasive 13C-Leucine Infusion-Technique allows quantitative information about protein decarboxylation as well as the dynamics of the protein metabolism like protein synthesis, protein oxidation, protein degradation and protein retention. In clinical research it is possible to compare the quality of different nutrition regimen with regard to protein-sparing effects by this method without irritation of the patient and without interrupting his nutrition. Two clinical investigations had been performed at the Surgical University Clinic Mannheim to study postoperative protein metabolism:

1. on the influence of different carbohydrates (Xylitol/Glucose) concerning postoperative protein metabolism during a hypocaloric nutrition regimen and
2. on the course of the individual postoperative protein metabolism during different phases after the operation and in comparison of two requirement-adapted nutrition regimen.

Results

1. Our first study showed no influence of the applied carbohydrate (Xylitol or Glucose) to the postoperative protein metabolism.
2. The comparison of a peripheral-venous nutrition regimen composed of maltose (12%), amino acid solution (7%) and fat (20%) (2,000 kcal, 650 mosm/l) with a central-venous nutrition regimen composed of glucose/laevulose/xylitol (40%) and amino acid solution (7%) (2,000 kcal, >2,000 mosm/l) showed no changes in postoperative protein metabolism. Contrary to the accumulated nitrogen balance the 13C-Leucine-Tracer-Technique showed still a light catabolism even on the fifth day after operation.

Introduction

Investigations of the last years showed that the determination of the ‘classic’ parameters of the protein metabolism like amino acid analysis, nitrogen balances, analysis of the short lived proteins, often cannot give exact and quantitative results. Because ethical reasons do not allow the use of radioactive tracers for \textit{in vivo} investigations anymore, stable isotopes have been established in clinical research more and more. The non-invasive 13C-Leucine-Tracer-Technique yields quantitative information about protein decarboxylation and dynamics of the protein metabolism such as protein synthesis, protein oxidation, protein degradation and protein...
retention [1–3]. For example with this method it is possible to compare the quality of different nutrition regimen with regard to their protein-sparing effect without bothering the patient and without interrupting his (e.g., parenteral) nutrition.

During the last two years two clinical randomised studies had been performed with the $^{13}$C-Leucine Tracer-technique in order to study the postoperative protein metabolism rising two questions:
1. Do different carbohydrates (Glucose or Xylitol) take influence on the postoperative protein metabolism in a hypocaloric nutrition regimen?
2. Does a requirement-adapted parenteral nutrition (2,000 kcal) applied by peripheral-venous catheter and composed of maltose (12%), amino acids (7%) and fat (20%) have the same effects on postoperative protein metabolism as an isocaloric parenteral nutrition applied by a central venous catheter?
3. Is it possible to compare accumulated nitrogen balances with the results of the $^{13}$C-Leucine-Tracer-Technique with regard to protein retention and catabolism.

Materials and Methods

Essential reasons for the use of $^{13}$C-labelled Leucine are:

1. Leucine as an essential amino acid is not synthesised by the organism itself, that means plasma levels of leucine only can be maintained by exogenous intake or proteolysis; an additional effect is the regulatory influence of leucine on the other branched chain amino acids [3,4].

2. The very special biochemical breakdown of leucine (Fig. 1). The first step in breakdown is the deamination to α-cetoisocaprate; this is a reversible step which takes place in the muscle. As supplier of amino acids, muscle tissue plays the most important part in maintenance of their homeostasis.

The next (irreversible) step is the decarboxylation, done in the liver into iso-valeryl-coenzyme A (which leads into the citric-acid circle after decomposition to acetyl-coenzyme A) and $\text{CO}_2$, which will be expired through the lungs.

![Leucine metabolism diagram](image)

Fig. 1. L-(1-$^{13}$C)-leucine metabolism.