Nutritional Assessment and Techniques

Topic 3

Module 3.2

Body Composition

Yitshal Berner
Rémy Meier
Lubos Sobotka
Nachum Vaisman

Learning Objectives

- Assumptions and application of techniques for the measurement of body composition;
- To have knowledge on their precision and limitations;
- To be informed about the two-, three- and four-compartment models for body composition.

Contents

Key Messages

- In vivo body composition measurements are always indirect, based on one or more assumptions concerning the nature of the body components fat mass and fat-free mass;
- The other methods are all double-indirect, validated against indirect methods, and therefore based on more assumptions;
- Whatever method is used, the starting point is the measurement of body mass with a calibrated scale;
- Subsequent subdivision of body mass in components like fat mass and fat-free mass has an accuracy of 1 kg or less, especially in patients where assumptions are often violated.

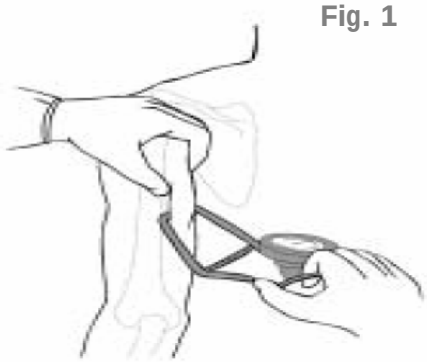
1. Anthropometry

This measures the anatomical changes associated with change in nutritional status (1):

- Body weight;
- Involuntary weight loss over three months;
- < 5% mild ; >10% severe malnutrition;
- Body Mass Index (BMI): BMI = Wt (kg) / Ht^2 (m^2);
- Midarm circumference (MAC);
- Triceps skin fold thickness (TSF);
- Densitometry;
- Total body water measurement (TBW);
- Total body electrical conductivity (TOBEC);
- Body impedance (BI);
- Dual energy X-ray absorptiometry (DEXA).

Measurement of triceps skin fold with caliper

Fig. 1



Measurement of body composition is important tool for evaluating the patient's nutritional status on admission and for measurement of the efficacy of his nutritional intervention on follow-up. Measurements can be done on different levels: atomic, tissue, cellular, molecular, or the whole body level. In clinical settings, the mostly used methods include the whole body approach or the tissue-system approach. The latter can be studied in a 2-compartment model or a more detailed one; the 4-compartment approach.

1.1 The two-compartment model

The two compartments include the body fat mass (FM) and the fat-free body mass (FFBM). The latter is almost identical to the lean body mass (LBM).

1.2 The four-compartment model

The four-compartment approach further breaks down the fat-free mass into three sub-compartments: body cell, extra-cellular water and bone.

2. The methods of measurement

The methods of body composition measurement are based on biochemical and physiological characteristics. Some of these methods measure directly the specific component, but others are derived from other measurements, based on specific physiological assumptions. Understanding the background and the rationale behind a method can help in the interpretation of the results.

2.1 Underwater weighing

Underwater weighing or air displacement plethysmography can help in obtaining the two compartments: FM and FFBM.

2.2 MRI and CT scan

MRI and quantitative CT can also measure FM directly.

2.3 Subcutaneous fat skin folds measurement

Indirectly, FM can be derived from measurements of 2-4 sites of subcutaneous fat skin folds.

2.4 Dual energy X-ray absorptiometry (DEXA)

FFM and FM as well as the bone can be measured by the DEXA (method that uses two levels of X-ray energy and separates the compartments based on the different attenuation of the X-ray energy in a tissue–specific manner.

2.5 Body water measurement

Based on the assumption that cell hydration is constant (73% of the cell) measurements of total body water and its two components: extra cellular and intracellular, can be used to derive FM.
Total body water can be studied by dilution method - isotopic labeling of water (^3H_2O, ^3H_2O, $H_2{}^{18}O$) or by the bioelectrical impedance method (BIA). Extracellular water can be measured by the dilution method (bromide space) or using BIA. Bone mass can be assessed directly by calcium neutron activation method or indirectly by DEXA and body cell mass can be directly assessed by whole body potassium and nitrogen neutron activation, or indirectly by measuring intracellular water.

2.6 Muscle mass measurement

Muscle mass can be estimated by creatinine excretion or 3-methyl histidine excretion in the urine.
Choosing the proper method to study body composition depends on availability, the question asked and the ability to interpret the results.

2.7 Body impedance

Body impedance is a technique that can be used for routine bedside measurement of body composition. It is based on differences in conducting properties of different tissues. Tissues containing large amounts of water and electrolytes are good conductors. Fat mass, air or bones are poor conductive materials.

- At low frequencies the current is unable to penetrate the cell membrane and resistance is negatively related to the extracellular fluid;
- At higher frequencies the current is able to pass through the cell membrane and the measured resistance is reflection of total body water;
- Finally, the measured resistance values at low and high frequencies can be used to calculate ECW and TBW. These compartments can be used for calculation of fat mass (FM) and fat free mass (FFM).

References

1. Basics in Clinical Nutrition Sobotka L.(edit),3rd edition, 2004, Galen
2. Goodpaster BH. Measuring body fat distribution and content in humans. Curr Opin Clin Nutr Metab Care 2002: 5; 481
3. Wang ZM, et al. The five-level model: a new approach to organizing body-composition research. Am J Clint Nutr 1992:56:19
4. Mazess RB, et al. Dual-energy x-ray absorption for total-body and regional bone mineral and soft tissue composition. Am J Clin Nutr 1990: 51; 1106
5. Schoeller DA. Bioelectrical impedance analysis. What does it measure? Ann NY Acad Sci 2000:904; 159
6. Kyle et. al. Bioelectrical impedance analysis-part I. Clin Nutr. 2004 23:1226