Impact of hydration status on body composition in patients before and after haemodialysis as measured by dual energy X-ray absorptiometry

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Aims and objectives

The aim of this study was to evaluate the impact of haemodialysis on the estimation of body composition using dual-energy X-ray absorptiometry (DXA) as a model to understand whether variations in soft tissue hydration cause errors in fat mass assessment by DXA.

DXA is a low-cost, accurate, easy to perform and widely available technique that allows to quantify bone mass and soft tissue with very low radiation dose to the patient; all these advantages make this densitometric method ideal for clinical use and longitudinal studies.

DXA machine uses a source that generates X-rays at two energies, a detector, and an interface with a computer system for imaging the scanned areas of interest. The underlying concept of DXA technology is that photon attenuation in vivo is a function of tissue composition. Rectilinear scanning divides the body into a series of pixels, within each of which the photon attenuation is measured at two different energies. The ratio of the attenuations at these two energies is referred to as the R value.

DXA measurements are based on the molecular level that can be simplified in a three-compartment model with fat mass (FM), non-bone lean mass (LM) and bone mineral content (BMC) (Fig. 1 on page 3) (1,2); each of these components are distinguishable by their X-ray attenuation properties.

Within any pixel, the proportions of only two components can be resolved by the differential absorption of two photon energies. Soft tissues, consisting largely of water and organic compounds, reduce photon flux much lesser than bone, and pixels containing bone are relatively easily distinguished from those with no bone present. In areas where bone is not present, suitable calibration allows fat and lean fractions to be resolved from soft tissue. The composition of these areas of soft tissue is extrapolated to the soft tissue overlying bone to produce total body fat and lean soft tissue (3).

DXA technique can measure FM, LM, BMC not only in the whole body but also in specific regions of the body and this is of great interest because it is well known that the distribution of bone, lean and fat mass is not uniform throughout the body.

Now, a fundamental assumption is that the soft tissue is normally hydrated for accurate partitioning into fat and lean fractions (4,5).

DXA soft tissue analysis algorithms assume that 73.2% of the lean body mass is water (6). However, hydration can vary from 67% to 85% and, in patients with fluid retention or with severe overhydration, such as ascites or oedema, this is a potential source of errors. As a consequence, the error in lean body mass quantification causes a proportionally larger error in estimating fat.
So DXA is gaining international acceptance as a body composition reference method but an important and incompletely resolved question is the influence of hydration status on the quantification of soft tissues’ components (FM and LM) by DXA (7).

Images for this section:

![Fig. 1: Dual-energy x-ray absorptiometry whole-body analysis. The body is conventionally represented by coloured areas according to the percentage of fat mass. In the colour scale, ranging from red (low fat mass percentage) to yellow (high fat mass percentage), red is set for regions with composition under 25% of fat mass, orange for regions between 25% and 60% of fat, and yellow for fat over 60%. According to the regional assessment of body composition the figure shows U as upper limbs, T as trunk, L as lower limbs. A and G stand respectively for android and gynoid.](image-url)
Methods and materials

Twenty-two patients (9 men, 13 women), age 64.5±15.2 years-old, BMI 27.0±4.3 Kg/m², underwent a whole-body DXA scan (Lunar iDXA) immediately before and 2 hours after haemodialysis.

Both whole-body and regional measures of the three components of body composition (FM, LM and BMC) were obtained and analyzed.

Only changes greater than the least significant change (LSC) were considered as statistically significant.

Results

The average removing of ultrafiltrate between pre- and post-haemodialysis was approximately 2.1 L (2.8% of the total body mass) (Fig. 2 on page 4).

A statistically significant change of total non-bone lean mass was observed (-4.9%), especially in the leg compartment (-6.5%).

No statistically significant change was found for total fat mass (0.3%), and for the regional fat mass of arms (0.6%), trunk (-1.0%), android (-0.8%), and gynoid (0.9%) (Fig. 3 on page 6).

Images for this section:
**Fig. 2:** The figure shows the changes of total-body mass (in grams) pre- and post-haemodialysis: the average loss of total-body mass was approximately 2.1 Kg. The total-body fat mass did not present a statistically significant change between pre and post-haemodialysis, while a statistically significant change in total-body lean mass was observed (-4.9%).

![Graph showing changes in lean mass pre-dialysis and post-dialysis](image)

**Fig. 3:** A statistically significant change of total non-bone lean mass was observed especially in the leg compartment (-6.5%) while in the other compartments these modifications are less important.
Conclusion

Hydration status must be considered when measurements of lean body mass are performed.

The major rate of fluid mobilization was recorded in legs because of the dependence on venous competence and muscle tone against gravity, and also because of the posture during the dialysis session itself.

The fat estimation errors due to variation in soft tissue hydration was also present but it was minor than the LSC; and this should not represent a limitation to the accuracy of DXA in clinical practice.

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References


