Measuring Changes in Organ Composition Using Dual Energy X-Ray Absorptiometry: Potential for Rodent Studies on Alcoholism

Our aim was to test whether or not dual-energy x-ray absorptiometry (DEXA) was capable of measuring changes in the livers, hearts and kidneys of laboratory rats exposed to long-term alcohol ingestion. We dissected nine male rats of a strain (Long Evans, weight 480–530 g) that will later be used in studies of alcoholism. We used a PIXImus DEXA apparatus to measure organ composition. DEXA was found to be a plausible tool for measuring and identifying the sort of composition changes that may occur in the liver, heart and kidney as a result of prolonged exposure to alcohol.

Student Researcher: Jolene Jackinsky
Mentor: Ian Van Tets, PhD

Introduction

Long-term use of alcohol can result in changes to tissue composition in the liver, heart and kidneys. The liver becomes enlarged, fattened and scarred resulting in a decrease of lean tissue mass and an increase in fat tissue mass.[1] The heart is enlarged, resulting in an increase of lean tissue mass. The kidneys enlarge and fatten, leading to an increase in fat tissue mass.[2]

Dual-energy x-ray absorptiometry (DEXA) has been used successfully in studies of whole body composition in small live animals such as birds, mice and rats.[2–4] This technique works by combining two energy types: photoelectric absorption and Compton scattering. Photoelectric absorption differentiates the soft tissue from the bone and Compton scattering can differentiate between fat tissue or lean tissue. By combining measurements of these two energy types, it is possible to measure bone mineral density, bone mineral composition, lean tissue mass, fat tissue mass, percentage lean tissue and percentage fat.[2–5]

Our aim was to test whether DEXA was capable of measuring changes caused by alcohol abuse in the liver, heart and kidneys. We hypothesized that DEXA would measure organ composition with sufficient precision and consistency to make it a useful tool for future studies that compared control rats and rats exposed to alcohol.

Methods

We dissected nine male Long Evans (*Rattus norvegicas*) rats and used a PIXImus DEXA apparatus to measure the composition of their livers, hearts and kidneys. The rats were all slightly overweight and ranged in whole body weights from 480–530 grams. They had been euthanized with carbon dioxide for reasons unrelated to our project and our use of the dead rats was approved by the UAA Institutional Animal Care and Use Committee (IACUC protocol 2004vante1).

The rats were kept frozen at −20 °C until use and the desired organs removed and weighed on a balance. The organs were x-rayed using the PIXImus apparatus, which automatically transferred the data to the Lunar PIXImus software program. Once the organs had been x-rayed, we placed them in labeled plastic bags and stored them at −20 °C. After all three organs of all nine rats had been x-rayed, we transferred the data for analysis with Microsoft Excel and calculated the mean values and standard deviations for lean tissue mass, fat tissue mass and total tissue mass. We also calculated the means and standard deviations for percentage fat for each organ.

Data Analysis

Table 1 shows the mean values ± the standard deviation for each organ's composition. Table 2 shows the mean values ± standard deviation for each organ's percentage tissue.

Results

The liver is a larger organ than the heart and kidneys and has mass measurements larger than those for the heart and kidneys (Table 1). The percentage fat was similar for all three organs and is thus likely to be a good indicator of the level of fat to expect on a normal

From the University of Alaska Anchorage; Anchorage, Alaska.

Table 1. Lean mass vs fat mass for the liver, kidneys and heart

	Liver	Left Kidney	Right Kidney	Heart
Lean tissue (g)	17.0 ± 1.4	1.8 ± 0.2	1.8 ± 0.2	1.7 ± 0.1
Fat tissue (g)	5.3 ± 0.6	0.5 ± 0.2	0.5 ± 0.1	0.4 ± 0.1
Total tissue (g)	22.3 ± 1.7	2.2 ± 0.3	2.3 ± 0.2	2.1 ± 0.1

rat of this strain (Table 2). The level of variation as expressed by the standard deviation was low for lean tissue mass and fat tissue mass for all three organs.

CONCLUSIONS

This project demonstrated DEXA's potential in future studies on the effects of alcoholism. The low level of variation will enable the detection and measurement of even small differences between the organ composition of control rats and of alcoholic rats. We expect that lean tissue mass will decrease and fat tissue mass will increase in rats that are given alcohol over an extended period and that DEXA will be able to identify and measure these changes. Future studies will be able to use DEXA to compare rats exposed to alcohol to control rats.

By demonstrating the viability of DEXA as a tool for measuring small changes in organ composition in rats, this project will help those studying the physiological effects of alcohol abuse in humans. The effects of alcohol on organ composition are similar in rats and humans. DEXA is capable of detecting and measuring even small changes in lean tissue mass, fat tissue mass and the percentage of fat tissue in an organ. These are the types of organ composition changes in the liver, heart and kidneys that could be expected from long-term abuse of alcohol in humans.

Table 2. Fat as a percent of total tissue in the liver, kidneys and heart

	Liver	L Kidney	R Kidney	Heart
Mean (%)	23.8 ± 2.2	19.7 ± 5.5	22.8 ± 2.4	19.4 ± 2.7

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