Use of 1H MRS of vertebra in vivo in determining bone weakening

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Introduction

It is suggested and supported in the literature that bone strength in multi-factorial and may depend not only on bone density but also on bone marrow quality [1-2]. It has been shown that osteoporosis is associated with increased fat content in the bone marrow [3-6]. Increased vertebral marrow fat may express bone weakening [7]. Line width (~1/T2*) is related to trabecular orientation and density which influence the microscopic homogeneity of the magnetic field inside the marrow [8-13]. Increased bone density is expected to cause greater magnetic field inhomogeneity and wider spectral peaks. Conversely, decreased bone density makes signal peaks narrower.

Methods

Seventy-two subjects (33 male and 39 female; age 15-87) and 22 abnormal subjects (15 male and 7 female; age 26-80) are studied. All subjects in this study had 1H MRS as well as routine Lumbar MRI. Subjects are considered normal if MRI findings are negative. The abnormal subjects are those who have MRI findings of prominent Schmorl’s nodes (n=14), endplate depression (n=1), wedging of vertebrae (n=4) and vertebral body compression fractures (n=3). 1H MRS technique and voxel placement were described in detail in a previous papers [14]. Normally L2 was chosen for acquiring spectroscopy. If L2 was compressed or otherwise altered in structure, one of the neighboring vertebrae was used. All measurements were performed on a Siemens Vision 1.5 T system (Erlangen, Germany). A quadrature spine array coil was used for signal reception. The stimulated echo acquisition mode (STEAM) sequence was used to acquiring spectroscopy. The parameters are TR/TE 5000/20 msec, bandwidth 1000 Hz, data points 1024, voxel size 1 cm3, total acquisition time 3 minutes or less. Both % Fat fraction (FF) and Line width data were obtained for further statistical analysis. Line width is measured of full width at half maximum of the water peak. Statistical evaluation was conducted using Student t-test.

Results

Within the normal subjects, there is a linear increase of %FF with age. Males have a higher %FF than females in all age categories. This gender difference is most pronounced in 4th & 5th (P<0.025) subgroup. The gender difference is very significant for the total group of 72 normal subjects (P<0.01).

Between the normal and abnormal groups, % FF is consistently higher for abnormal subjects in all age subgroups. The differences are very significant for 4th & 5th (P<0.0005) and 8th & 9th (P<0.02) subgroups. Subsequently, difference in %FF is very significant (P<0.0005) between the two entire groups. Line width is almost identical in the 4th &5th and 6th& 7th decades. Line width is higher in the 8th & 9th decade (40 Hz) and was lowest in the 2nd &3rd decade (25.9 Hz). While there were some gender difference, these showed no trend. Interestingly, the line width of abnormal subiects is significantly larger that that of normal subjects in 4th & 5th decade (P=0.05). Further more, difference in line width is very significant between the two entire groups.

Discussion

Our current age dependence fat content in normal subjects supports the previous report [14]. So does the gender dependence fat content in normal subjects. Increased fat content among the male gender could be interpreted as denoting bone weakening. This is not realistic and is contrary to clinical experience. We believe that increased marrow's fat found in males are a constitutional phenomenon and reflects the normal tissue structure for men. It is known that increased marrow fat content can lead to bone weakening. It is also well known that conversion of red to yellow bone marrow with aging. In osteoporosis, an increase in bone marrow fat cannot be ignored [5]. Histological and histomorphometrical measurements on osteoporotic vertebrae showed decrease in cancellous bone accompanied by a decrease in hemopoietic marrow and a corresponding increase in fat cells. Further report even observed that with aging the increase in marrow fat is more marked than the fall in cellular marrow[14].

Conclusions:

Linear increase of %FF with age and gender difference in age 4th and 5th groups in %FF are further confirmed by our current larger data pool in normal spine vertebrae. %FF is a useful index in diagnosing bone weakening in age in age 4th&5th and 8th&9th decades. Both trends are clear and expected to apply to other age groups with more data points. In contrast, line width data do not show general trend and may not be a sensitive index in diagnosing bone weakening.

References

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