MR Imaging Study of Relationships Between Lumbar Bone Density, Paravertebral Muscle Bulk and Perfusion Indices in Postmenopausal Osteoporosis

S. Yang[1], J. F. Griffith[1], D. Yeung[1]

[1]Diagnostic Radiology and Organ Imaging, The Chinese University of Hong Kong, Shatin, Hong Kong, China, People's Republic of

INTRODUCTION:

Loss of skeletal muscle mass (i.e. sarcopenia) [1] and reduced bone density with increased bone fragility (i.e. osteoporosis) are both features of aging. Are they related or do they occur independently of each other? Is there any relationship between lumbar muscle mass and blood flow? This study addressed these questions through study of the interrelationships among sarcopenia, osteoporosis, and perfusion indices of the lumbar spine in female elderly patients of similar age.

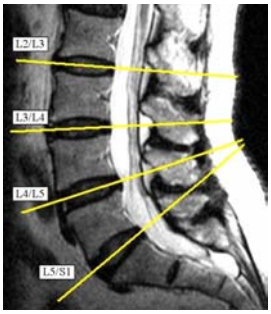

Figure 1. Sagittal T2-weighted MR image of the lumbar spine showing levels at which the paravertebral muscle cross-sectional area was measured.

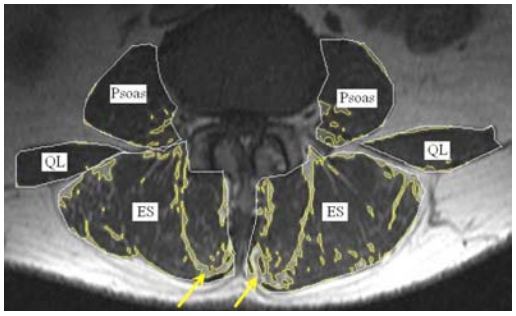

Figure 2. Axial T1-weighted MR image at the L3/4 disc level. The psoas, quadratus lumborum (QL) and erector spinae (ES) muscles are marked. The more hyperintense areas within the boundaries represent adipose tissue (arrows), while the remaining tissue represents lean muscle.

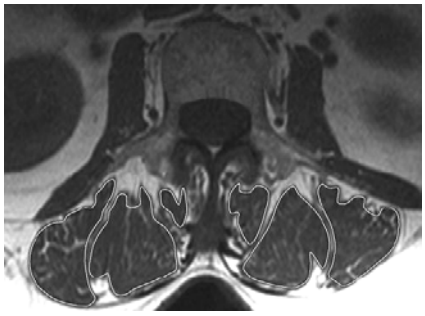

Figure 3. Axial T1-weighted MR image of the lumbar spine at L3 showing a manually drawn ROI encompassing the individual components of the erector spinae muscle for time intensity data-points measured from DCE-MRI.

MATERIALS AND METHODS:

36 female subjects (mean age 72 years, range 67-83 years) underwent DXA examination and MRI of the lumbar spine was performed on a 1.5-T whole-body system. According to WHO criteria, 12 subjects were classified as normal bone density, 12 as osteopenia, and 12 as osteoporosis. Following segmentation, cross-sectional area of the psoas, quadratus lumborum and erector spinae was measured at four levels (L2/3, L3/4, L4/5 and L5/S1) (Fig. 1). Muscle cross-sectional area (CSA) was used as an indicator of lumbar muscle mass (Fig. 2). On the mid-axial T1-weighted image (TR/TE, 450/1), ROIs were drawn separately encompassing the three elements of erector spinae to calculate muscle perfusion respectively (Fig. 3).

Dynamic contrast-enhanced MR imaging (DCE-MRI) was performed on a single slice in the axial plane through the mid-L3 region. Images were obtained using a short T1-weighted gradient-echo sequence (TR/TE, 2.7/0.95; pre-pulse TI, 400 msec; θ, 15°; section thickness, 10 mm; FOV 250 mm; matrix, 256 × 256; one NEX). A bolus of gadoteric acid at a concentration of 0.15 mmol/kg was injected at a rate of 2.5 mL/sec. On the mid-axial T1W image, ROIs separately encompassing the three elements of the erector spinae muscle were drawn manually (Fig 3). Maximum enhancement (ME) and enhancement slope (ES) computed from time-intensity curve were used as semi-quantitative measures of perfusion. ME was defined as the maximum percentage increase in signal intensity from baseline (I_{base}). ES was defined as the rate of enhancement between 10% and 90% of the maximum signal intensity difference between maximum signal intensity (I_{max}) and I_{base}. These perfusion indices parameters were calculated thus:

$$ME = \frac{(I_{max} - I_{base})}{I_{base}} \cdot 100\% \qquad ES = \frac{(I_{max} - I_{base}) \cdot 0.8}{I_{base} \cdot (t_{90\%} - t_{10\%})} \cdot 100\%$$

where $t_{10\%}$ and $t_{90\%}$ are the time intervals when the rise in signal intensity reaches 10% and 90% of the maximum signal intensity difference between I_{base} and I_{max}, respectively. Both indices parameters are derived from the first-pass phase of signal enhancement and are considered to represent arrival of contrast material into the arteries and capillaries and its diffusion into the extracellular space. Muscle CSA and perfusion indices were correlated with bone mineral density, body mass index, degenerative disc disease severity (eight-point scale), presence of vertebral fracture, presence of low back pain (LBP), and level of physical activity (Physical Activity Score for the Elderly (PASE)). *t* test comparisons and Pearson correlation tests were applied.

RESULTS:

Paravertebral muscle CSA was reduced in subjects with reduced bone density (osteopenia or osteoporosis) compared to normal bone density subjects (p=0.03). However, comparison revealed no direct correlation between bone density and muscle CSA (p=0.96). Paravertebral muscle CSA did increase with increasing body mass index (R=0.34, p=0.04), with increasing level of physical activity (R=0.36, p=0.03) and also with vertebral fracture (p=0.04). Paravertebral muscle CSA was not related to severity of degenerative disc disease or the presence of low back pain. Erector spinae muscle perfusion was not related to bone density. Muscle perfusion parameters were significantly different (maximum enhancement: p=0.049, enhancement slope: p=0.043) depending on the level of disc degeneration. In line with the increasing severity of degeneration, the muscle perfusion parameters decrease. There was a trend that muscle perfusion increases with decreasing CSA of erector spinae, but no evident correlation was found (R=-0.321, p=0.056).

DISCUSSION AND CONCLUSIONS:

Paravertebral muscle bulk is generally decreased in subjects with reduced bone density but no direct correlation was found. Paravertebral muscle bulk was increased in those of larger body build, in those with higher levels of physical activity and also in those with vertebral fracture. This lattermost unexpected finding may be explained by increased muscular activity being requited to compensate for altered spinal biokinetics in subjects with fracture. An alternative explanation is that subjects who are more physically active (and therefore of higher muscle bulk) are more likely to fracture than less physically active subjects of comparable bone density. The increase in muscle perfusion indices observed in subjects with decreased muscle CSA might be explained by different time-intensity curve dynamics in smaller muscles. Muscle perfusion indices were inversely correlated with an eight-point scale of disc degeneration. Disc degeneration may adversely affect the mobility of lumbar spine, resulting in the decreased activity of paravertebral musculature and, as a result, a decrease in muscle perfusion indices. In conclusion, this study shows that paravertebral muscle bulk is generally decreased in subjects with osteopenia or osteoporosis compared to normal bone density subjects although the reverse is true for subjects with osteoporotic vertebral fracture. Paravertebral muscle bulk may influence time-intensity curve dynamics. Paravertebral muscle perfusion does seem to be indirectly affected by disc degeneration.

REFERENCES:

1. Song MY, *et al.*, Sacropenia and increased adipose tissue infiltration of muscle in elderly African American women. *Am J Clin Nutr* 2004; 79; 874-880.