Morphometric analysis of prostate zonal anatomy by magnetic resonance imaging (MRI): impact on age-related changes

Matsugasumi T1,2, Ukimura O1,2, Nakamoto M1, Shoji S1, Abreu A.L.C2, Suer E3, Palmer S1, Gill IS3
1 Institute of Urology, University of Southern California, Los Angeles, CA, USA
2 Department of Urology, Kyoto Prefectural University of Medicine, Kyoto, Japan

Introduction:

Magnetic resonance imaging (MRI) could reliably evaluate the McNeal’s prostate zonal anatomy. The aim of this study was to evaluate impact of the morphometric MRI-analysis of the prostate zonal anatomy on aging, prostatic hypertrophy.

Methods:

A total of 307 men, average age 68 years (43-92), including consecutive Japanese men (n=156) and American men (n=151), who had elevated PSA and underwent MRI with slice thickness of 3 mm prior to prostate biopsy in 2008-2014. Using Synapse Vincent version 2 (Fujifilm, Japan), the boundary of prostate zonal anatomy was segmented in each step section of T2-weighted MRI, to calculate following variables;

1) [PZ-vol. (ml)]: volume of whole gland prostate
2) [TZ-vol. (ml)]: volume of transition zone
3) [PZ-volume] (ml): volume of peripheral zone which includes both the peripheral zone and central zone of McNeal’s zonal anatomy
4) [PCAR]: Presumed Circle Area Ratio, which is defined as the ratio of the area in the maximum axial section of the prostate to that of a presumed circle with the equal circumference of the section. (PCAR evaluates how closely the shape of the section approaches a circle, and represents “increase of intra-prostatic pressure”)
5) [PZ-thickness] (mm): defined as PZ-volume divided by the maximum coronal section-area of prostate, by computerized-calculation from the reconstructed 3D-prostate volume

Results:

Table 1: MRI measure in comparison between Japan vs. USA

<table>
<thead>
<tr>
<th>Measure</th>
<th>Japan(n=156)</th>
<th>USA(n=151)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>68(61-74)</td>
<td>69(63-75)</td>
<td>0.68</td>
</tr>
<tr>
<td>PSA</td>
<td>6.6(0.5-37.8)</td>
<td>7.9(0.9-76.1)</td>
<td>0.004</td>
</tr>
<tr>
<td>PZ-vol.</td>
<td>46.3(20.9-93.9)</td>
<td>48.8(20.9-93.0)</td>
<td>0.003</td>
</tr>
<tr>
<td>TZ-vol.</td>
<td>22.1(4.9-102.7)</td>
<td>26.1(4.9-102.4)</td>
<td>0.001</td>
</tr>
<tr>
<td>PCAR</td>
<td>0.66(0.44-0.85)</td>
<td>0.83(0.44-0.85)</td>
<td>0.001</td>
</tr>
<tr>
<td>PZ-thickness</td>
<td>12.9(10.1-14.7)</td>
<td>13.4(10.1-14.7)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Figure 2: PCAR (presumed circle area ratio), which is defined as the ratio of the area in the maximum axial section of the prostate to that of a presumed circle with the equal circumference of the section, represents “increase of intra-prostatic pressure”.

Figure 3: Representative MRI of the prostate with the thinner thickness of PZ according to the greater PCAR (representing intra-prostatic pressure).

Results 2:

Table 2: Correlation between morphometric variables and LUTS. PCAR had the most significant relation with LUTS, followed by PZ-thickness and TZ-vol.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Japan(n=156)</th>
<th>USA(n=151)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPSS</td>
<td>r=0.38</td>
<td>r=0.25</td>
<td>0.001</td>
</tr>
<tr>
<td>PCAR</td>
<td>r=0.46</td>
<td>r=0.38</td>
<td>0.001</td>
</tr>
<tr>
<td>PZ-thickness</td>
<td>r=0.24</td>
<td>r=0.24</td>
<td>0.001</td>
</tr>
<tr>
<td>TZ-vol.</td>
<td>r=0.25</td>
<td>r=0.25</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Figure 4: The correlation between Age and PZ-vol.
PZ-vol. had no age-related increase in each country and entire cohort.

Figure 5: The correlation between TZ-vol. and PCAR. The greater TZ-vol. grows, the higher PCAR becomes

Figure 6: The correlation between TZ-vol. and PZ-thickness. The higher TZ-vol. becomes, the thinner PZ-thickness becomes.

Figure 7: The correlation between PCAR and PZ-thickness. The higher PCAR due to TZ-vol. becomes, the thinner PZ-thickness becomes.

Conclusion:

- PZ-volume had no age-related increase with age. The greater the TZ-volume grows, the higher the intra-prostatic pressure and the thinner the PZ-thickness become. MR-analysis of prostate zonal anatomy enhanced understanding of age-related changes of morphology.

Image References:

Figure 1: A T2-weighted MRI image (Figure 1A) and segmented whole gland prostate (Figure 1B) and transition zone (Figure 1C) for reconstruction of 3D model of the prostate zonal anatomy.

Figure 2: PCAR (presumed circle area ratio), which is defined as the ratio of the area in the maximum axial section of the prostate to that of a presumed circle with the equal circumference of the section, represents “increase of intra-prostatic pressure”.

Figure 3: Representative MRI of the prostate with the thinner thickness of PZ according to the greater PCAR (representing intra-prostatic pressure).

Figure 4: The correlation between Age and PZ-vol.
PZ-vol. had no age-related increase in each country and entire cohort.

Figure 5: The correlation between TZ-vol. and PCAR. The greater TZ-vol. grows, the higher PCAR becomes

Figure 6: The correlation between TZ-vol. and PZ-thickness. The higher TZ-vol. becomes, the thinner PZ-thickness becomes.

Figure 7: The correlation between PCAR and PZ-thickness. The higher PCAR due to TZ-vol. becomes, the thinner PZ-thickness becomes.