Prevalence of High Riding Vertebral Artery and Morphometry of C2 Vertebra Using The New CT Reconstruction Technique

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• Vertebral artery (VA) injury: serious complication of posterior atlantoaxial transarticular screw and C2 pedicle screw fixation
• VA groove anomaly: 2 anatomic variations
  - High riding vertebral artery (HRVA)
  - Narrow pedicle of C2
• Preoperative CT scan is helpful for identifying the variation of VA
Introduction (2)

• No standard CT protocol on technique of reconstruction preoperative CT scan and few previous studies compared these 2 techniques of CT scan measurement

<table>
<thead>
<tr>
<th>Conventional CT scan&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Thin-sliced pedicular-oriented CT scan&lt;sup&gt;2, 3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Not accurate</td>
<td>- Enables visualization of the entire path of the screw</td>
</tr>
<tr>
<td>- Some significant error</td>
<td>- Help identifying safe zone for screw placement</td>
</tr>
</tbody>
</table>

Purpose

• To compare the prevalence of C2 vertebral artery groove anomaly by using
  - Conventional CT scans
  - Thin-slice CT scans with pedicular-oriented plane

Study design

• Cross-sectional, comparative study using two different planes of CT scan
Methods (1)

320 CT scan of cervical spine of patients age ≥ 20 years during 2008-2011

Exclusion criteria
- Trauma, tumor, infection and congenital anomaly at upper cervical spine
- Severe metal artifact

200 CT scan of cervical spine

Reformatted CT scan

Conventional CT scan

Thin-sliced pedicular oriented CT scan

High Riding Vertebral Artery
- ≤ 5 mm of isthmus height and/or
  ≤ 2 mm of internal height on sagittal image

Narrow Pedicle Width
- ≤ 4 mm of largest pedicle width on axial CT scan

Compare Prevalence of VA groove anomaly (McNemar’s Test)
Methods (2)

Conventional CT scan

- Axial slice
  - 1 mm thickness with orthogonal horizontal plane
- Sagittal slice
  - 3 mm thickness with vertical to the coronal plane of the vertebral body

Thin-sliced pedicular-oriented CT Scan

- Axial slice
  - 1 mm fine slice along the long axis of C2 pedicle
- Sagittal slice
  - 1 mm fine slice at 1, 2 and 3 mm from lateral border of spinal canal
Axial slice in Thin-sliced pedicular-oriented plane (B) at the same level demonstrated full length of the pedicles bilaterally.
The measurement in conventional plane (C) shows that the pedicle is falsely thicker than in thin-sliced pedicular-oriented plane (D,E).
## Patient Demographics

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Male</td>
<td>109</td>
<td>54.5</td>
</tr>
<tr>
<td>- Female</td>
<td>91</td>
<td>45.5</td>
</tr>
<tr>
<td>Age* (years)</td>
<td>57.2 (20-90)</td>
<td></td>
</tr>
<tr>
<td>Original diseases of CT study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Thyroid and parathyroid</td>
<td>79</td>
<td>39.5</td>
</tr>
<tr>
<td>- Cervical spine</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>- Oropharynx</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>- Nasopharynx</td>
<td>21</td>
<td>10.5</td>
</tr>
<tr>
<td>- Other (^\delta)</td>
<td>48</td>
<td>24</td>
</tr>
</tbody>
</table>

*Mean (range)

\(^\delta\)Other diseases; dental, larynx, facial bone and sinus diseases
## Pedicle Width, Internal Height and Isthmus Height of C2 Vertebra

<table>
<thead>
<tr>
<th>Measured parameter</th>
<th>Measurement</th>
<th>Conventional CT (mean ± SD)</th>
<th>TPCT(^{\theta}) (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedicle width (mm.)</td>
<td></td>
<td>5.07 (± 1.31)</td>
<td>4.87(± 1.27)</td>
</tr>
<tr>
<td>Internal height (mm.)</td>
<td></td>
<td>5.61 (± 2.30)</td>
<td>5.27(± 1.61)*</td>
</tr>
<tr>
<td>Isthmus height (mm.)</td>
<td></td>
<td>10.18 (± 1.85)</td>
<td>10.28(± 1.61)*</td>
</tr>
</tbody>
</table>

\(^{\theta}\) Thin-sliced pedicular oriented CT scan

* value at sagittal cut at 2 mm from lateral border of spinal canal

\(^{\delta}\) value at sagittal cut at 3 mm from lateral border of spinal canal
## Prevalence of Narrow Pedicle of C2 and HRVA

<table>
<thead>
<tr>
<th>Type of VA groove anomaly</th>
<th>Conventional measurement</th>
<th>Thin-sliced pedicular-oriented measurement</th>
<th>P-Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow pedicles</td>
<td>15.58%</td>
<td>22.83%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>High riding vertebral artery</td>
<td>6.01%</td>
<td>16.54%</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

*McNemar’s test*
Conclusions

• Prevalence of vertebral artery groove anomaly is not uncommon
• Thin-sliced pedicular-oriented CT scan showed higher prevalence of VA groove anomaly and narrow pedicle of C2
• This technique should be considered as preoperative evaluation for safety of the C2 screws placement procedures.

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