Ultrasound lumbar canal measurement in hospital employees with back pain

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ABSTRACT The oblique parasagittal diameter of the lumbar spinal canal at the L5–S1 level was measured in 49 employees of the Wm Jennings Bryan Dorn Veterans’ Hospital using real time ultrasound in a case-control study. Individuals with a canal diameter of less than 14 mm represented the lowest 10th percentile in this population and being in the narrowest 10th percentile constituted a risk factor for time missed from work because of low back pain (odds ratio 10·7). Whereas numbers in this pilot study are small, results are consistent with earlier ultrasound studies done in the United Kingdom and with other research showing increased morbidity from low back pain in individuals with small lumbar canals. Ultrasound has advantages over other modalities for measuring the size of the lumbar canal and may be useful as a preplacement screening examination in industry.

Low back pain (LBP) is a common condition that costs industry billions of dollars annually in workers’ compensation claims alone. A few claims result in a disproportionate amount of cost. In a study of Boeing Company employees 10% of claims accounted for 79% of the total costs from LBP. If workers at increased risk for developing high cost back injuries could be identified before injury occurs special training or job placement, or both, might lower their risk of serious low back disability, which would reduce both employee suffering and employer costs.

An anatomically narrow lumbar spinal canal is associated with increased morbidity arising from at least three major conditions: intervertebral disc disease, neurogenic claudication (spinal stenosis syndrome), and root entrapment syndromes. The clinical importance of a stenotic lumbar canal has been increasingly understood in recent decades. The usefulness of this knowledge, however, has been severely limited by the difficulty in obtaining in vivo canal measurements without undue cost, exposure to radiation, or discomfort.

In 1978 Porter et al first showed that midsagittal lumbar spinal canal diameters could be measured by ultrasound. They determined that lumbar canals were smaller in patients with disc symptoms than in controls, and that the greater the morbidity the smaller the canal size. Macdonald et al, using ultrasound, looked at 204 British coalminers and also found a strong tie between narrow lumbar canals and increased morbidity from LBP. Since ultrasound examinations do not expose individuals to ionising radiation, and since the procedure is non-invasive, painless, and may be performed quickly and relatively inexpensively, it has decided advantages over other methods that may be used to measure canal diameters.

This case-control study was undertaken as a pilot project. Its purpose was twofold: to confirm the observations of Porter et al that ultrasound may, in fact, be used to measure lumbar spinal canal diameters accurately and to determine if an association between narrow lumbar canal diameters and time lost from work because of low back pain could be found in hospital workers (hospital workers do have a higher than usual incidence of low back injuries). It is hoped that a long term prospective cohort study of employees at a veterans’ hospital will follow.

Materials and methods

Subjects
Volunteers for the study were recruited from current employees of a VA hospital. Sixteen employees who had missed time from work in the past two years because of low back pain constituted the “back” group. The “control” group consisted of 23 employees who denied ever having had low back pain of consequence. Those with previous low back surgery (which distorts ultrasound images) were excluded. All
participants were interviewed at the time informed consent was obtained for the procedure. Those in the back group were asked if they had had radiation of their LBP into their buttock(s) or leg(s). No physical examination or record review was done.

The mean age for the back group was 42.9 years and 40.1 for the controls (p = 0.19). Mean height did not differ significantly between the groups (173 cm for the back group; 171 cm for controls), although the back group tended to weigh more than the controls—76.5 kg v 70.0 kg (p = 0.08). Mean Quetelet scores were 25.52 for the backs and 23.75 for the controls (p < 0.06). The back group differed significantly from the controls in having a greater proportion of jobs where lifting was routinely carried out (p = 0.005).

**PROCEDURE**

Two dimensional B-mode oblique parasagittal ultrasound images of the lumbar spine at the L5–S1 level were obtained using a Picker real time ultrasound machine with a 10-5 cm linear array transducer having a frequency of 3-5 megahertz. This standard equipment is used for a wide range of imaging procedures in a medium sized VA hospital. The L5–S1 level was readily identifiable in relation to the visualised sacrum using the linear array transducer. The transducer was placed 1 cm from the midline of the back and was angled medially approximately 15° to obtain the best image. Images were displayed both in A and B modes. The A-mode display is relative to the position of the cursor on the B-mode display, which should be positioned to conform with the B-mode image. Adjustments to the time delay gain were important to provide optimal display of the anterior and posterior canal margins. This had to be done subjectively on an individual basis. Images were recorded in a 6 on 1 format on to an 8 × 10 sheet of film using the Picker multiformat camera.

Imaging was more readily done with subjects in the sitting position (with backs flexed slightly to straighten the lumbar lordotic curve). Satisfactory studies could be completed in about five minutes compared with somewhat inferior studies in 35–45 minutes obtained from subjects in the prone position (where the lumbar lordosis could not be straightened even with pillows under the abdomen). The subjects much preferred the sitting position. This sitting technique for this purpose has not, to the authors’ knowledge, been previously reported.

**ANALYSIS**

Sixty three sitting studies were completed (20 backs and 43 controls). Eleven films of poor quality were excluded from analysis as were three that had incorrect or illegible identification labels. This left 49 studies for analysis (16 backs, 33 controls).

<table>
<thead>
<tr>
<th>Reader</th>
<th>No</th>
<th>Mean canal diameter (cm)</th>
<th>Standard deviation</th>
<th>Correlation coefficient (Coff DFA)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFA</td>
<td>49</td>
<td>1.68</td>
<td>0.24</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>DJA</td>
<td>49</td>
<td>1.68</td>
<td>0.24</td>
<td>0.90</td>
<td>0.81</td>
</tr>
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<td>JFF</td>
<td>27</td>
<td>1.73</td>
<td>0.25</td>
<td>0.81</td>
<td>0.66</td>
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</tbody>
</table>

All films were read by two of the authors, one the chief of the department of radiology at the University of South Carolina School of Medicine (DFA) and the other a boarded internist without special training in radiology (DJA). A second radiologist, the chief of radiology at the Wm Jennings Bryan Dorn Veterans’ Hospital (JFF), read 27 films. Measurements were estimated to the nearest 0.05 cm using an accompanying scale with each set of films. Analysis of interobserver error was made from the results of all three readers. Subsequent group and sub group analyses were performed using the measurements of just one of the authors (DFA). He was totally blinded as to the identity of the films (DJA was not) and he read all the films (JFF did not).

**Results**

**INTEROBSERVER VARIATION** (table 1)
The mean diameter for the group (cm) was 1.68, 1.68, and 1.73 for each reader (DFA, DJA, and JFF). Correlation analysis was performed and the correlation coefficient as compared with DFA values was 0.90 (r² = 0.81) for DJA, and 0.81 (r² = 0.66) for JFF. The correlation coefficient for DJA compared with JFF was 0.87 (r² = 0.76). This was thought to represent a high degree of correlation between readers.

**GROUP RESULTS** (table 2)
The mean L5–S1 canal diameter for the group (n = 49) was 1.68 cm (SD 0.24), with a range of 1.15–2.20 cm (figure). For the backs, the mean diameter was smaller than the controls—1.60 cm (SD 0.25) v 1.72 cm (SD 0.23) (p = 0.05). The four smallest canal diameters were all from the back group (p < 0.01). The lowest 10th percentile for the group was found to include diameters of 1.35 cm or less. The odds ratio for being in the lowest 10th percentile and having missed

<table>
<thead>
<tr>
<th>No</th>
<th>L5–S1 canal diameter (cm)</th>
<th>Standard deviation</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total group</td>
<td>49</td>
<td>1.68</td>
<td>0.24</td>
</tr>
<tr>
<td>Back group</td>
<td>16</td>
<td>1.60</td>
<td>0.25</td>
</tr>
<tr>
<td>Control group</td>
<td>33</td>
<td>1.72</td>
<td>0.23</td>
</tr>
</tbody>
</table>
time from work because of low back pain was calculated to be 10.7.

Canal diameters within the back subgroup (n = 16) were examined in relation to the questionnaire response indicating either radiation of the pain into the buttock or leg (n = 7) or non-radiation of pain (n = 9). No difference was observed between the groups (1.60 vs 1.59 cm).

**Table 3 Results by sex**

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>$L_5-S_1$ canal diameter (cm)</th>
<th>Standard deviation</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>26</td>
<td>1.68</td>
<td>0.28</td>
<td>0.53</td>
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<tr>
<td>Women</td>
<td>23</td>
<td>1.67</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Men:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back</td>
<td>9</td>
<td>1.54</td>
<td>0.27</td>
<td>0.03</td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>1.75</td>
<td>0.26</td>
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</tr>
<tr>
<td>Women:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back</td>
<td>7</td>
<td>1.67</td>
<td>0.20</td>
<td>0.48</td>
</tr>
<tr>
<td>Control</td>
<td>16</td>
<td>1.68</td>
<td>0.19</td>
<td></td>
</tr>
</tbody>
</table>

**Distribution of canal diameters.**

X = History of missed time from work due to low back pain (n=16)
O = No history of low back pain (n=33)

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>$L_5-S_1$ canal diameter (cm)</th>
<th>Standard deviation</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whites</td>
<td>38</td>
<td>1.68</td>
<td>0.23</td>
<td>0.5</td>
</tr>
<tr>
<td>Non-whites</td>
<td>11</td>
<td>1.68</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Whites:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back</td>
<td>11</td>
<td>1.57</td>
<td>0.24</td>
<td>0.03</td>
</tr>
<tr>
<td>Control</td>
<td>27</td>
<td>1.72</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Non-whites:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back</td>
<td>5</td>
<td>1.66</td>
<td>0.28</td>
<td>0.43</td>
</tr>
<tr>
<td>Control</td>
<td>6</td>
<td>1.69</td>
<td>0.27</td>
<td></td>
</tr>
</tbody>
</table>

1.68 cm. On the other hand, nine men in the back group had a mean $L_5-S_1$ diameter of 1.54 cm compared with 1.75 cm in the 17 male controls. This is a statistically significant difference ($p = 0.029$).

**BY RACE (table 4)**

No difference in canal size was noted between 38 whites and 11 non-whites. The mean canal diameter at the $L_5-S_1$ level for each subgroup was 1.68 cm. Eleven whites in the back subgroup had a significantly smaller mean canal diameter than 27 control whites—1.57 cm vs 1.72 cm ($p = 0.03$). Five non-whites in the back subgroup had a mean diameter less than six control non-whites—1.66 cm vs 1.69 cm. This was not a significant difference, however ($p = 0.43$).

**Discussion**

Results from this case-control pilot study must be considered in the light of the weaknesses of the study itself, probably the most significant being the few people studied. Eleven films were not included in the analysis because the quality was too poor to permit reliable measurement and this was done with the agreement of two of the readers (DFA and DJA). Some were of obese subjects, the thickness of adipose tissue severely limiting the quality of the study. Most of the remaining poor films, primarily due to inexperience with the technique, came during the early days of the study. Refinements in technique were rather easily accomplished with experience. Measurements were best made from the A-mode display. Optimally, images might also be recorded on videotape for review and assessment of quality.

While this study has its limitations, it is significant that the results obtained are consistent with those reported elsewhere. For example, the lowest 10th percentile diameter at the $L_5-S_1$ level in the series of Porter et al was also below 1.4 cm, and 14 mm is considered to be the lower level of normal for the AP diameter of the lumbar spine as determined by myelography and by plain x-ray films. Results are also consistent with those of Porter and Mac-
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Donald, using ultrasound, and Kornberg and Winston using other modalities (computed tomography and lumbosacral x rays, respectively) that link narrow spinal canals with increased morbidity from low back problems. In the present study being in the lowest 10th percentile for canal diameter was significantly associated with an increased likelihood of having missed time from work because of low back pain (odds ratio 10-7).

It is noteworthy that we could obtain such results in a pilot study after minimal training, using the technician and equipment of an ordinary hospital radiology department. We believe that, with some minor modifications of the recording programme to permit easier measurement, accuracy and interobserver consistency could be further improved.

The reasons for an association between small canal size and low back pain are not entirely clear but probably reflect the neural content/canal ratio. Free space exists between the outer bony/ligamentous lining of the lumbar and the dura and other inner linings, permitting tension free movements of neural contents within the spinal canal. This has been termed the "spinal reserve capacity." As determined by computed tomography, the spinal reserve capacity is about 0.74 mm at the L3 and L4 levels and extremely variable at L5. Anything that would reduce this capacity could produce "disproportionately severe clinical signs." People with intrinsically narrow canals would probably have less spinal reserve capacity to start with, so it would take less of an insult (such as a smaller bulge of the annulus fibrosis, a lesser degree of osteophyte intrusion into the canal, or even the normal narrowing of the canal from age related periosteal calcification) to produce symptoms in those individuals than in those starting with wider canals.

This study confirms that it would be practicable to undertake further large scale studies to determine whether canal size could be of use as a screening test for preventing back problems. If those in the smallest 10th percentile can be proved to be at increased risk of developing low back pain (particularly if they can be shown to be the few cases that constitute the greatest expense), ultrasound could become a valuable screening tool in industry, permitting selective job placement or protective training, or both, for those at high risk.

We thank Kenneth Heinz for performing the ultrasound studies and Mrs Gwendolyn Sharpe for her help in identifying hospital personnel eligible to take part in the study.

References

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