The Occurrence of Annular Tears and their Relation to Lifetime Back Pain History

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Spine, 2004 (Revised version submitted)
Professor Tapio Videman
Lumbar Spinal Pathology in Cadaveric material in Relation to History of Back Pain, Occupation, and Physical Loading

Tapio Videman, Markku Nurminen and J.G.D Troup
Spine Vol. 15, 1990
State of the knowledge using all available diagnostics tools

85% of patients have nonspecific diagnoses, a few percent have herniated discs or spinal stenosis; all other diagnoses account for 9%

High prevalence of abnormal scanner image findings among subjects without back pain

Â Jarvik et al. Spine 2001; Vol 26. (MRI)
Â Powell et al. Lancet 1986; Vol 2. (MRI)
Â Weinreb et al. Radiology 1989; Vol 170. (MRI)
Â Wiesel et al. Spine 1984; Vol 9. (CAT)
Diagnostic value of imaging is very limited for non-specific back pain

- Presence of annular tear counted for 6% of the variation in the frequency of back pain in the past 12 months and was not associated with current back pain.
  

- The presence of a high-intensity zone does not reliably indicate the presence of symptomatic internal disc disruption.
  
Objectives: The 1990 Study

Â­ To test the hypothesis that minimal pathologic changes are caused by exposure to physical loading between extremes of overexertion and inactivity

Â­ To relate the spinal pathology findings to occupational physical loading
Objectives: The 2004 Study

Å To study the occurrence of lumbar annular tears (severity of outcome and level of disc) by age

Å To analyse the relation of lifetime back pain frequency to discographic findings
Hypotheses

Å Tears reaching at most to the inner annulus are not related to discogenic pain

Å Tears extending to but not beyond the outer annulus have a weak relation to pain

Å Full annular ruptures or “leaking” tears are highly related to discogenic pain
Spinal Pathologic Outcomes

- Annular ruptures
- Symmetric disc degeneration
- End-plate defects
- Vertebral osteophytosis
- Facet joint osteoarthrosis
Occupational Risk Factors

- Physical loading by type of work
- Heavy work before 20 years of age
- Chemical exposures

Effect Modifying Factors

- Aging
- Physical excercises
Causal Model

Occupational Risk Factors → Spinal Pathologic Outcomes

Effect Modifying Factors
Estimated Model for Heavy Work and Annular Tears

Heavy work before age 20 \( \geq 3 \) years

\[ \text{OR} = 2.5 \ (0.3-21) \]

\rightarrow

Annular tears

\[ \text{OR} = 1.4 \ (0.7-3.1) \]

\rightarrow

Injury causing disability

\[ \text{OR} = 10 \ (1-100) \]

\rightarrow

Aging by 10 years
Risk Measures

Absolute Risk (R)

Relative Risk

Risk Ratio (RR) = Risk in Index Category / Risk in Referent Category

= $P_I / P_R$

Odds Ratio (OR) = $[P_I / (1-P_I)] / [P_R / (1-P_R)]$
Interpretation of the Point Estimate

Point estimate:

Annular ruptures are common (> 50%)
⇒ OR = 10 is an overestimate

If the dynamic study population is stable regarding the exposure and covariates over the risk period, then OR is unbiased.
Interpretation of the Interval Estimate

Back Injury → Annular Rupture

Interval estimate, 95%:

\[ OR_{\text{lower}} = 1 \leq OR \leq 100 = OR_{\text{upper}} \]

\[ OR_{\text{lower}} \geq 1 \iff \text{2-sided p-value} = 5\% \]

Materials and Methods

157 cadavers of men who died in the wards or clinics of the University Hospital, Helsinki, and examined in the Central Laboratory of Pathology

86 cases with information on lifetime back pain history provided by subject's family

581 disc pathologies classified using BaSO$_4$ discography, radiology, and osteology
Exclusion Criteria

- Not of working age (≥ 64 years)
- Not employed before death
- Chronic illness or hospitalization
- Death from cancer or infectious disease
Selection of subjects of working age and who died after a brief illness limited the time gap between occupational exposure and pathodologic outcome. Thus it secured that no pathodologic changes had occurred due to illness.
Lifetime history of Back Pain

Questions:
Did he have back pain? If so, how often?
Was he unable to work for at least 1 month because of back pain or injury?

Reply alternatives:
No back pain, 38%
Sometimes — less than once a year, 26%
Often — at least once a year, 36%
Unable to work — Yes (16%) or No (84%)
Question:
Did he do heavy physical work before the age of 20? If so, for how long?

Reply alternatives:
No, 21%
Yes — less than 3 years, 20%
Yes — 3 years or more, 41%
Not known, 18%
Anulus Fibrosis

- Alternating directions
- 10-20 lamellae
- At 65 degrees angle
Classification of Annular Tears

0. None

I. Slight: Spread as far as the middle of the annulus

II. Moderate: Spread to the outer contour off the annulus

III. Severe: Leakage outside the contour of the annulus
Results I : Description

Occurrence of Annular Tears
Probability of Any Annular Tear by Age

Age, years

Probability of Any Annular Tear by Age

Probability

Age, years

20 30 40 50 60
Probability of Annular Tear by Extent of Finding and Age
Probability of Annular Tear by Level of Disc and Age
<table>
<thead>
<tr>
<th>Spine level</th>
<th>Occupational Physical Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sedentary</td>
</tr>
<tr>
<td>L1-L3</td>
<td>0.11</td>
</tr>
<tr>
<td>L3-S1</td>
<td>0.24</td>
</tr>
</tbody>
</table>
Results II : Analysis

Back Pain in Relation to Annular Tears and Occupational Physical Loading
## Probability of Back Pain History

*Proportional Odds Logistic Regression*

<table>
<thead>
<tr>
<th>Severity of Tear</th>
<th>Frequency of Lifetime Back Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
</tr>
<tr>
<td>Inner</td>
<td>0.75</td>
</tr>
<tr>
<td>Outer</td>
<td>0.55</td>
</tr>
<tr>
<td>Leaking</td>
<td>0.29</td>
</tr>
</tbody>
</table>

*P = 0.0009*
# Probability of Back Pain History

*Proportional Odds Logistic Regression*

<table>
<thead>
<tr>
<th>Work Load</th>
<th>Frequency of Lifetime Back Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
</tr>
<tr>
<td>Sedentary</td>
<td>0.53</td>
</tr>
<tr>
<td>Light</td>
<td>0.56</td>
</tr>
<tr>
<td>Driving</td>
<td>0.24</td>
</tr>
<tr>
<td>Heavy</td>
<td>0.22</td>
</tr>
</tbody>
</table>

*P = 0.04*
Etiologic Model: Summary

*Annular tears* bore a highly significant ($P < 0.001$) relation to the frequency of back pain.

*Occupational physical loading* was just significant ($P = 0.04$).

*Aging* was not significant ($P = 0.4$).
## Frequent Back Pain

<table>
<thead>
<tr>
<th>Worst Tear</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner</td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Outer</td>
<td>11</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Leaking</td>
<td>37</td>
<td>22</td>
<td>59</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>27</td>
<td>80</td>
</tr>
</tbody>
</table>
Etiologic Model

\[ P( \text{Frequent pain} = \text{Yes} \mid \text{Worst tear} = \text{Leaking} ) \]

\[ = \frac{22}{29} = 37\% \]

Prevalences

\[ P( \text{Worst tear} = \text{Leaking} ) = \frac{59}{82} = 72\% \]

\[ P( \text{Frequent pain} = \text{Yes} ) = \frac{27}{82} = 33\% \]
Diagnostic Model via Bayes Rule

\[ P( \text{Worst tear} = \text{Leaking} \mid \text{Frequent pain} = \text{Yes} ) = \]
\[ P( \text{Frequent pain} = \text{Yes} \mid \text{Worst tear} = \text{Leaking} ) \times \]
\[ P( \text{Worst tear} = \text{Leaking} ) / P(\text{Frequent pain} = \text{Yes} ) \]
\[ = 0.37 \times 0.72 / 0.33 = 81\% \]

\[ P( \text{Worst tear} = \text{Leaking} \mid \text{Frequent pain} = \text{No} ) = \]
\[ P( \text{Frequent pain} = \text{No} \mid \text{Worst tear} = \text{Leaking} ) \times \]
\[ P( \text{Worst tear} = \text{Leaking} ) / P(\text{Frequent pain} = \text{No} ) \]
\[ = 0.37 \times 0.72 / 0.67 = 40\% \]
Diagnostic Model: Summary

*With* a history of frequent back pain the probability that the worst annular tear is leaking is 92%.

*Without* such a history the corresponding probability is 45%.
Discussion Points

The results of this study do not confirm the mechanism of back pain, but:

full annular rupture of the disc is required that substances from the nucleus pulposus can expose nerve tissues and cause inflammation

as well as for ingrowth of granulation tissue into the nucleus pulposus
Discussion Points (cont)

From these data, we cannot determine precisely the age at which first annular tears appear. But, we know that the youngest person—aged 21 years—already had inner tears at levels L1-L3.

The substantive genetic influences in most degenerative disc findings suggest that predisposed persons develop disc pathology significantly earlier than the rest.
Key Points

- Identifiable structural changes of the lumbar discs likely begin in adolescence.

- There is a large variation in the occurrence of annular tears at all ages.

- Current diagnostics may not be adequate to detect fully ruptured annular tears.
Key Points (cont'd)

Annular leaking is highly related to the history of frequent back pain

Heavy physical loading is mainly an aggravating factor of back pain and has only a minor effect on disc tears
Thank you.