Back pain and disc degeneration as manifestations of cardiovascular disease.

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Topics:

1. Statistics
2. Blood supply of the lumbar spine
3. Disc degeneration
4. Atherosclerosis in the aorta
5. Vascular disease and lower back pain
6. How to examine
7. Take-home ideas
Statistics: lower back pain

- Annual incidence: 5%
- Point-prevalence: 15-25%
- One-year prevalence: 20-65%
- Lifetime prevalence: 60-90%

Williams et al 2015, Shiue 2015, Goubert et al 2004
Statistics: lower back pain, etiology

• Specific : 10 - 20%
  – disc prolapse
  – spinal stenosis
  – infections
  – tumors

• Non-specific : 80 – 90%
Blood supply of the lumbar spine

- Lumbar arteries
- Middle sacral artery
Blood supply of the lumbar spine
3 main branches of lumbar arteries:

1. **posterior body wall**
   - paraspinal muscles, subcutaneous tissue, skin

2. **vertebral body and nerve root**
   - vertebral bone, nerve root, posterior root ganglion

3. **posterior peritoneum**
   - psoas and quadratum lumborum muscles
1. branch to posterior body wall

**Paraspinal muscle ischemia:**
- pain related to exercise
- failure to remove waste products, accumulation of lactic acid

→ muscle atrophy
→ fat degeneration
2. branch to vertebral body and nerve root

bone ischemia:
- dull, constant pain
- stasis, oedema
  (Modic changes in MRI)
- bone sclerosis,
  end-plate sclerosis
- disc degeneration

nerve root ischemia:
- sciatica, radicular pain
Nutrient supply of the intervertebral disc

Vertebral body
Lumbar artery
Disc
Lumbar artery
3. Branch to posterior peritoneum

Posterior peritoneum ischemia:

- lateral back pain
- pain related to psoas and quadratum lumborum muscle activity
Blood supply of the spinal cord:

Arteria Adamkiewiecz

Most commonly 2-3 arteries from thoracic segmental arteries
Statistics: atherosclerosis

Most common locations:

1. the lower abdominal aorta
2. coronary arteries
3. popliteal arteries
4. the descending thoracic aorta
5. the internal carotid arteries

the Bogalusa Heart Study 2015, Vihert 1976, Ross 1988, Berenson GS 1998:
Statistics: prevalence of aortic atherosclerosis

5 centers, 17,300 aortas
(Malmö, Sweden; Praque, Czechoslovakia; Ryazan, Russia; Yalta, Ukrainia; Tallin, Estonia)

< 5 yrs: fatty streaks
20 yrs: 10% have fibrous plaques

30 – 45 yrs: greatest increase of fibrous plaques

44 – 64 yrs: greatest increase of complicated lesions

WHO: Vihert 1976, Zhdanov et al. 1998
Atherosclerosis: lesions in the abdominal aorta

Fatty streak  fibrous plaques  complicated lesion

Kauppila et al, Spine 1994
Atherosclerosis: stenosis of ostia of lumbar arteries
Atherosclerosis: lesions in the abdominal aorta

fibrous plaques  calcified lesions

Kauppila et al, Spine 1994
Atherosclerosis: calcification in the aorta
lumbar lateral x-ray - a window to arterial disease
Prevalence of Aortic Calcifications by Age
Framingham heart study

L. Kauppila et. al: Atherosclerosis 1997
Atherosclerosis and disc degeneration

45 year-old man with chronic low-back pain

lateral lumbar x-ray

MR image
Atherosclerosis and disc degeneration

CT images of necrotic intervertebral disc and disc degeneration
# Atherosclerosis and disc degeneration: Aortic calcification and disc deterioration

**The Framingham study**

<table>
<thead>
<tr>
<th>Disc deterioration between exams</th>
<th>Adjusted OR</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level specific aortic calcification at baseline</td>
<td>1.49</td>
<td>1.26 – 1.77</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Level-specific aortic calcification over follow-up</td>
<td>1.48</td>
<td>1.02 – 1.64</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Any aortic calcification over follow-up</td>
<td>2.02</td>
<td>1.16 – 3.51</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Kauppila et al, Spine 1997
# Atherosclerosis and lower back pain

## Back pain by aortic calcification

**The Framingham study**

<table>
<thead>
<tr>
<th>Back pain during adult life</th>
<th>Radiograph at Follow-up</th>
<th>Adjusted OR</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic calcification</td>
<td></td>
<td>1.56</td>
<td>1.10 - 2.21</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Kaupilia et al, Spine 1997
**Cardiovascular risk factors and disc herniation**

Nurses health study (n = 98,400, follow-up 16 yrs)

subjects with physician-diagnosed lumbar disc herniation

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Multivariate RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>diabetes</td>
<td>1.52</td>
</tr>
<tr>
<td>hypertension</td>
<td>1.25</td>
</tr>
<tr>
<td>high cholesterol</td>
<td>1.26</td>
</tr>
<tr>
<td>parent with MI before age 60</td>
<td>1.13</td>
</tr>
</tbody>
</table>
Atherosclerosis and lower back pain:

**Other studies**

Aortic calcification is 2.6 times more common in patients with lower back pain than in age-matched controls

Kurunlahti et al, Spine 1999

**Embolization for angiomatous spinal lesions:**

- severe back pain, muscle spasm, acute scoliosis for 3 - 5 days

Doppman & Di Chiro Radiology 1976

**Lumbar paraspinal myonecrosis; vertebral body infarctions**

- severe back pain

Atherosclerosis and disc degeneration:

• **MR aortography and serum cholesterol levels in patients with long-term non-specific lower back pain.**

  – Disc degeneration was associated with occluded lumbar and middle sacral arteries \( (p = 0.035) \).
  
  – Patients with above normal LDL cholesterol had more severe neurogenic symptoms \( (p = 0.031) \); more often severe back pain \( (p = 0.049) \); and more often occluded arteries \( (p = 0.020) \).

Kauppila et al, 2004
MR angiographic studies

3-year follow-up of lumbar artery occlusion with MR angiography in patients with sciatica: associations between occlusion and patient-reported symptoms.

lumbar arterial occlusion was strongly and consistently associated with patient-reported symptoms.

Kurunlahti et al, Spine 2004
Atherosclerosis and disc degeneration: Epidemiological studies

Cardiovascular risk factors and sciatica

A systematic review (22 papers): sciatica was associated with obesity, long smoking history, high serum C-reactive protein

Shiri R et al, Eur Spine J 2007

Serum lipids and sciatica

In men sciatica was associated with high total chol., LDL-chol., and triglyserides; in women with pharmacologically treated hyperlipidemia (N=8028)

Atherosclerosis and back disorders: **Smoking**

- Smoking is associated with nonspecific LBP according to 2 systematic literature reviews
  
  Leboeuf-Yde, Spine 1999  
  Goldberg, Scott, Mayo, Spine 2000

- Smokers have 18% greater mean disc degeneration scores than nonsmokers
  
  Battié et al, Spine 1991

- Disc herniation increases with the number of cigarettes smoked per day (98,407 female nurses; 16-yrs follow-up)
  
  Jhawar et al, Spine J 2006
### Multivariate relative risks of lumbar disc herniation by smoking status

Nurses health study (n = 98 400, follow-up 16 yrs)

<table>
<thead>
<tr>
<th>Smoking Status</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>nonsmoker</td>
<td>ref.</td>
<td>-</td>
</tr>
<tr>
<td>ex-smoker</td>
<td>1.10</td>
<td>1.00-1.20</td>
</tr>
<tr>
<td>current smokers</td>
<td>1.38</td>
<td>1.26-1.52</td>
</tr>
<tr>
<td>5-14 sigarettes/day</td>
<td>1.42</td>
<td>1.21-1.66</td>
</tr>
<tr>
<td>15-24</td>
<td>1.40</td>
<td>1.24-1.59</td>
</tr>
<tr>
<td>25-34</td>
<td>1.27</td>
<td>1.06-1.52</td>
</tr>
<tr>
<td>35-45</td>
<td>1.49</td>
<td>1.17-1.90</td>
</tr>
<tr>
<td>46+</td>
<td>2.14</td>
<td>1.34-3.42</td>
</tr>
<tr>
<td>p for trend</td>
<td>1.01</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Cardiovascular risk factors and lower back disorders epidemiological studies in 2006-15

- Obesity / radicular pain
- Diabetes / disc herniation
- Hypertension/ disc herniation
- High cholesterol/ disc herniation
- High LDL cholesterol / disc degeneration
- High C-reactive protein / radicular pain
- Carotid intima-media thickness / radicular pain
- History of cardiovascular disease / chronic low-back pain
- brachial-ankle pulse wave velocity (baPWV) / disc herniation

How to visualize lumbar arteries?
DSA aortography
DSA aortography

normal

missing arteries
MR aortography
Postmortem angiography

normal

stenotic/occluded

Kauppila & Tallroth, J Spin Dis 1993
Lateral lumbar x-ray

- quick low-cost routine examination
- safe (low dose of radiation, < 1mSv)
- reproducible
- suitable for clinical practice - and for scientific studies
- shows the progress of atherosclerosis

Abdominal Aortic Calcification Score (AAC score)
Arterial narrowing

- tissue dysfunction
- hypoxia
- failure to remove waste products

collateral formation

improved blood flow

adjusted work output

inactivity

- muscle atrophy
- disc degeneration
- nerve root ischaemia
- bone ischaemia

no symptoms

no symptoms

symptoms
Bypass or collateral arteries

- small arterial pathways open
- help to restore blood supply
- prevent degenerative changes
- run in paraspinal muscles and ligaments
- may run between several segments
Collateral arteries
Collateral arteries run between vertebral bodies
Collateral arteries between vertebral bodies

- normal avascular disc
- degenerated disc with vascular channels
Abdominal Aortic Aneurysm

- May cause both acute and chronic interruption of lumbar blood flow
- Develops in aorta gradually with atherosclerosis, allows time for collateral arteries to develop:
  - Descending arteries from intercostal and superior mesenteric arteries
  - Ascending arteries from iliolumbar and deep iliac circumflex arteries
- Ruptured AAA causes back and/or abdominal pain

Metcalfe et al 2015
Bypass grafts
### Lower back pain in AAA and HAO

*Takeyachi et al Surg Neurol 2006*

<table>
<thead>
<tr>
<th>Low back pain</th>
<th>High aortic occlusion</th>
<th>Abdominal aortic aneurysm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before surgery</strong></td>
<td>77%</td>
<td>32%</td>
</tr>
<tr>
<td><strong>After surgery</strong></td>
<td>26%</td>
<td>23%</td>
</tr>
</tbody>
</table>
Postoperative pain in AAA

- 4% of patients after surgery for AAA have muscle infarction

  → severe lower back pain, elevated levels of creatine phosphokinase

Bertrand et al 1997
The prevalence of lumbar vascular disease?

- Annual incidence: 5%
- Point-prevalence: 15-25%
- One-year prevalence: 20-65%
- Lifetime prevalence: 60-90%

Specific back pain: 10 - 20%
- Disc prolapse
- Spinal stenosis
- Infections
- Tumors

Non-specific back pain: 80 - 90%

10% = 13 500 000 patients/year in US
Treatment of lumbar artery disease

• **exercise**
  – Helps to open collateral (bypass) arteries

• **balloon angioplasty**?
  – blood flow not strong enough to keep arteries open?

• **Growth factors**?
  - induce angiogenesis and arteriogenesis
Take-home ideas

- Aortic atherosclerosis is common
- Atheromatous plaques obliterate orifices of arteries that supply the lumbar spine
- Opening of collateral arteries limits symptoms and ischemic damage
- Symptoms vary according to tissues suffering from ischemia
- Intervertebral disc is likely to be the first structure to degenerate
- Causes lots of pain and disability
Prevention