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MR Aortography and Serum Cholesterol Levels in Patients With Long-Term Nonspecific Lower Back Pain

Leena I. Kauppila MD, PhD,* Raija Mikkonen, MD, PhD,† Pekka Mankinen, MD,†† Kia Pelto-Vasenius, MD, PhD,* and Ilkka Mäenpää, MD‡

Study Design. A cross-sectional analysis of the feeding arteries of the lumbar spine and cholesterol levels on patients with long-term nonspecific lower back pain.

Objectives. To evaluate whether occlusion of lumbar and middle sacral arteries or serum cholesterol levels are associated with lower back pain and/or with disc degeneration.

Summary of Background Data. Atherosclerosis in the wall of the abdominal aorta usually develops at the ostia of branching arteries and the bifurcation, and may obliterate orifices of lumbar and middle sacral arteries. Obstruction of these arteries causes ischemia in the lumbar spine and may result in back symptoms and disc degeneration.

Methods. MR aortography and cholesterol blood tests were performed on 51 patients with long-term lower back pain without specific findings (*i.e.,* spinal or nerve root compression) in regular lumbar MR images. The patients ranged from 35 to 70 years of age (mean age, 56 years). Serum cholesterol and low-density lipoprotein (LDL) cholesterol levels were measured. To assess symptoms and disability NASS low back Outcome Instrument was used.

Results. Twenty-nine (78%) of 37 men and 11 (77%) of 14 women showed occluded lumbar and/or middle sacral arteries. The prevalence of occluded arteries was 2.5 times more than in subjects of corresponding age group in a Finnish necropsy material. Twenty-three (62%) men and seven (50%) women had significant disc degeneration. Disc degeneration was associated with occluded lumbar/middle sacral arteries ($P = 0.035$). Patients with occluded arteries or significant disc degeneration did not complain more severe symptoms than those without, whereas patients with above normal serum LDL cholesterol scored higher in neurogenic symptoms ($P = 0.031$) and complained more often severe pain ($P = 0.049$) than those with normal LDL cholesterol.

Conclusions. The study indicates that lumbar and middle sacral arteries are often occluded in patients with nonspecific long-term lower back pain. Occlusion of these arteries may also be associated with disc degeneration.

Key words: back pain, disc degeneration, MR aortography, lumbar arteries. **Spine 2004;29:2147–2152**

Epidemiologic and postmortem studies indicate that atheromatous lesions in the abdominal aorta may be related to disc degeneration and long-term back symptoms.[1–3] It has also been reported that some risk factors for atherosclerosis, such as low apo AI and high triglyceride, are associated with sickness absence because of back pain,[4] although this is not a consistent finding.[5] In an epidemiologic study on Finnish adults more than 29 years old, no association was found between low back pain and subsequent cardiovascular mortality, indicating that back pain is not associated with generalized atherosclerosis.[6] In these studies, the lack of distinction between different types of back pain was likely to bias the findings toward null.

The blood supply of the lumbar spine is derived from the aorta through the lumbar and middle sacral arteries. The upper four segments of the lumbar spine receive their blood supply from the four pairs of the lumbar arteries, which arise in the posterior wall of the abdominal aorta. The fifth lumbar segment is supplied partly by the middle sacral artery (arising in the bifurcation) and partly by branches of the iliolumbar arteries (arising from the internal iliac arteries).[7,8] Nutrition of the avascular intervertebral disc is by diffusion through the vertebral endplates from the blood vessels in the vertebral bodies above and below the disc.[9,10] Cholesterol plaques in the wall of the aorta obliterate orifices of lumbar and middle sacral arteries and may decrease blood supply of the lumbar spine and its surrounding structures. Structures with precarious nutrient supply, such as the intervertebral discs, may also suffer and gradually degenerate.[11–13]

Lumbar disc degeneration begins early in life. Severe macroscopic changes are already visible from the age of 30 onwards.[14] Atherosclerosis also manifests itself at middle age or even earlier in the abdominal aorta. Atheromatous plaques usually form at the orifices of branching arteries.[12,15] When occurring in or around ostia of lumbar or middle sacral arteries, they may reduce blood supply to the lumbar spine. Reduced blood flow causes hypoxia and tissue dysfunction. It also hampers removal of waste products, such as lactic acid. These changes in turn may irritate nociceptive nerve endings, causing pain, as well as lead to deterioration and atrophy of the structures involved.

From the Departments of Rehabilitation and Radiology, Helsinki University Central Hospital, Jorvi Hospital, Espoo, Finland; and the Division of Vascular Surgery, Department of Surgery, Helsinki University Central Hospital, Jorvi Hospital, Espoo, Finland.
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Address correspondence and reprint requests to Leena I. Kauppila, MD, Department of Rehabilitation, HUCH, Jorvi Hospital, Turuntie 150, 02740 Espoo, Finland; E-mail: leena.kauppila@hus.fi

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The aims of this study were to assess whether occlusion of the lumbar and/or middle sacral arteries or serum cholesterol levels are associated with long-term nonspecific lower back pain and/or with disc degeneration.

■ Patients and Methods

Patients. A total of 51 MR aortographies were performed on 37 men and 14 women at the department of Radiology in Jorvi Hospital (part of Helsinki University Central Hospital). These patients had been referred to the outpatient clinic of physiatrics at this hospital by primary care physicians who, after preliminary clinical and radiologic examination, had considered patients' back symptoms severe enough to require further examination. Participants were consecutive patients of one of the authors (L.I.K.), fulfilling the following criteria: they were from 35 to 70 years of age, had had long-term (over 3 months) lower back pain with or without leg pain, their symptoms at the time of the first visit to the clinic were regarded severe enough to require MR imaging, and this examination did not show specific findings, such as nerve root compression by disc prolapse/protrusion, spinal stenosis, infection, or tumors. In cases with questionable nerve root compression, electroneuromyography was performed to rule out patients with nerve root compression. The study was approved by the hospital's ethics committee. Informed consent was provided by all the patients.

Questionnaire. A questionnaire containing parts of the NASS (North American Spine Society) Low Back Outcome Instrument baseline questions, including also Oswestry Disability Index questions (version 2.0)[16,17] were given to patients to be completed at the outpatient clinic before the MR aortography. These questionnaires survey a patient's back and leg symptoms and disability in the past week. A summative score for neurogenic symptoms (scale 1–6; high score equaling worse neurogenic symptoms), and for disability index (scale 0–100; high score equaling greater disability) was calculated. Since NASS questionnaire concentrates on the frequency of symptoms in the past week, we added a question to provide more information on pain during the past 4 weeks. The question was as follows: "During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?: 1) not at all; 2) a little bit; 3) moderately; 4) quite a bit; and 5) extremely." This question is widely used in other health surveys, *i.e.*, in RAND 36-item Health Survey.[18,19]

Assessment of Disc Degeneration. A radiologist (P.M.) assessed disc degeneration from regular lumbar T2-weighted MR midsagittal fast spin-echo (repetition time 4000–5000 milliseconds/echo time 120 milliseconds) images, which were performed by MRI scanner with a field strength of 1.5 Tesla (Siemens Magnetom Symphony, Siemens AG, Erlangen, Germany). We used classification of lumbar intervertebral disc degeneration suggested by Pfirrmann et al.[20] In their validated classification, disc degeneration is assessed on routine T2-weighted MR images using the five grade classification. For our study, we selected Grade V to indicate significant disc degeneration. Because of the age range of our subjects, Grade I through III disc degeneration was seen in every spine and Grade IV in 46 of 51 (90%) spines. In Pfirrmann's classification, Grade V disc degeneration means that the structure of the disc is inhomogeneous, with a hypointense black signal intensity, the distinction between nucleus and anulus is lost, and the disc space is collapsed.

MR Aortography. MR aortography was performed by MRI scanner with a field strength of 1.5 Tesla (Siemens Magnetom Symphony, Siemens AG, Erlangen, Germany). This examination was made within 3 months after the regular lumbar MR imaging. In this examination, a scout with a turboflash technique (TR 1315 milliseconds, TE 4.2 milliseconds, TI 670 milliseconds, FA 15 deg) was taken to localize the abdominal aorta and the vertebral column. The time interval for exact timing of the contrast enhanced three-dimensional angiography was determined with a "test bolus-sequence." The sequence, turboflash (TR 1000, TE 4.2, TI 515, FA 10 deg) with a 10-mm-thick slice was taken, one slice per second, 40 slices at the level of the first lumbar vertebra. The intravenous injection of 2 mL of contrast medium (Magnevist, Schering, Germany, containing 469 mg gadolinium/mL), followed by 20 mL of 0.9% natrium chloride solution at a rate of 2.5 mL/sec was started simultaneously with the sequence. The peak T1 intensity of the test bolus was determined from a circular area in the aorta drawn by the computer.

The contrast-enhanced MR aortography was made with a three-dimensional turboflash technique (TR 4.0, TE 1.65 milliseconds, TD 6757 milliseconds FA 25 deg, SLAP thickness 150 mm, 18 seconds). Three measurements were made. The first measurement was made without contrast medium to be used for subtraction. The next two measurements (corresponding to arterial and venous phases) were made with contrast medium (20 mL of Magnevist), followed by 20 mL of 0.9% natrium chloride solution injected at a rate of 2.5 mL/sec.

The first measurement was subtracted from the second and third ones, and 12 sagittal MIP images (maximum intensity projection) were made, covering 360° axially. The arteries were analyzed from these images, as well as at the workstation screen both at coronal, oblique, and axial planes (Virtuoso, Siemens AG, Erlangen, Germany) (Figures 1 and 2). All the measurements and analyses were made by the same radiologist (R.M.), who was unaware of subjects' demographic variables, symptoms, and findings in regular lumbar MR images. The number of missing lumbar arteries were counted (from 0 to 8). The middle sacral artery was scored as absent or present (0 or 1).

Other Variables. Information about weight and height were collected in connection with the outpatient visit. Blood tests for serum total cholesterol and low-density lipoprotein (LDL) cholesterol were collected after 12 hours of fasting. Smoking habits were available from the questionnaire.

Statistical Analysis. Statistical analyses were performed using SPSS for windows, version 11.5 statistical software.[21] To analyze categorical variables, $\div^2$ distribution and Fisher's exact test (2-sided) were used. To compare continuous outcome variables between two groups Student's *t* test (2-tailed) was used. A Mann-Whitney rank sum test was used for comparing scores for neurogenic symptoms and disability in groups with and without occluded arteries, with and without significant disc degeneration, and with and without high cholesterol/LDL cholesterol levels. Because one of the parameters of interest was the association between occluded arteries and disc degeneration, which both tend to increase with age, we tested the homogeneity of the material by comparing the prevalence of findings in

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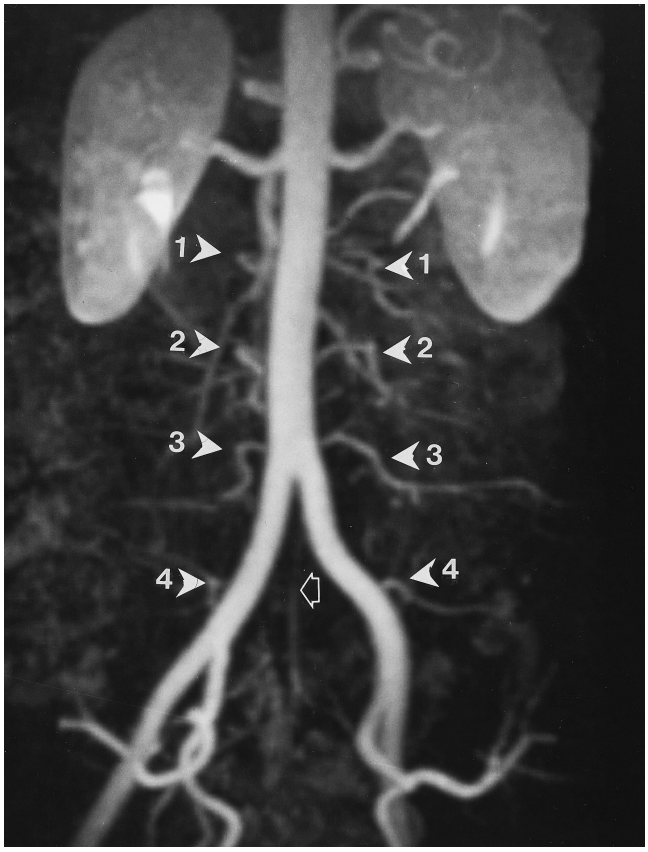

Figure 1. MR aortography. Coronal view shows four pairs of lumbar arteries, the lowest pair, fourth lumbar arteries, exceptionally originate from the common iliac arteries. Hollow arrow points to the middle sacral artery.

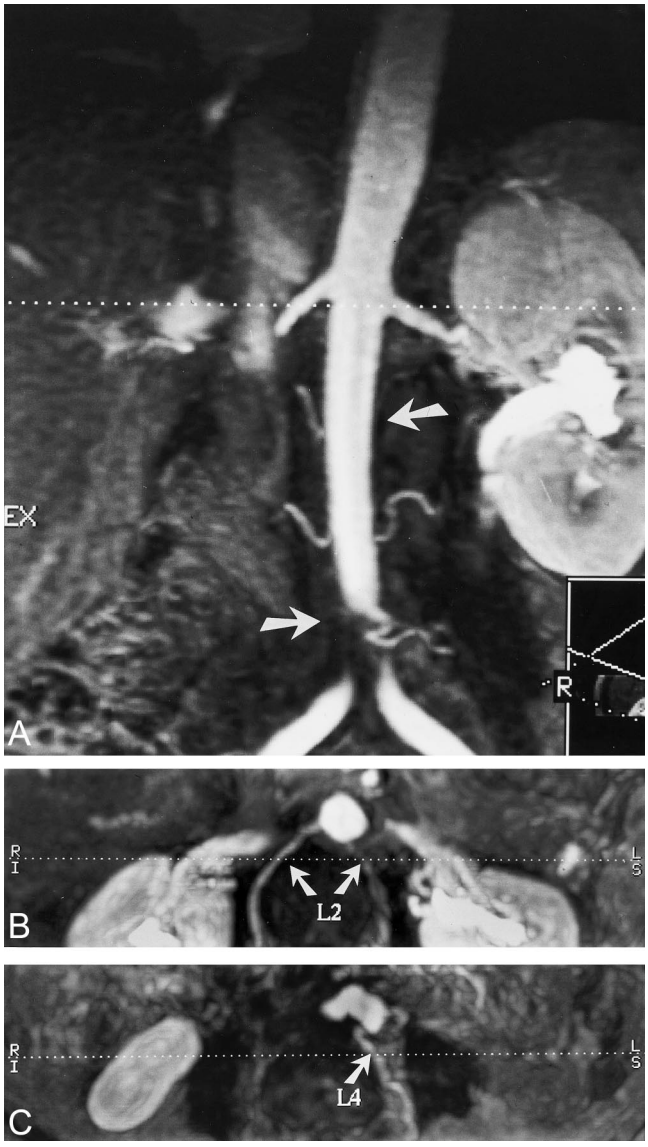

Figure 2. The left second and right fourth lumbar arteries are not visible in coronal plane (**A**). Axial view shows normal second lumbar arteries (**B**), whereas the right fourth artery is occluded (**C**). The first lumbar arteries were normal, situating behind the renal arteries.

the groups below and above the median age. *P* values less than 0.05 were considered significant.

■ Results

Demographic characteristics of the patients are shown in Table 1. Thirty-seven men and 14 women did not differ in age, smoking habits, body mass index, or serum cholesterol levels. Twelve men and 5 women had lower back pain without leg pain, and 25 men and 9 women had also pain in one or both legs (meaning pain in thigh, calf, ankle, and/or foot). When patients below and above median age (≤56 years; >56) were compared, no differences were found in the body mass index, cholesterol levels, smoking habits, number of intervertebral discs with significant degeneration, number of occluded lumbar/middle sacral arteries, or scores for neurogenic symptoms, disability index, and pain.

When asked about neurogenic symptoms, men scored, on average, 3.4 (SD 0.9), and women 3.2 (SD 1.0). Disability index scores were 49 (SD 14) for men and 46 (SD 10) for women. Both the neurogenic symptoms and disability index scores indicate that these patients had, on average, considerably severe symptoms. When asked about how much pain had interfered with their normal work during the past 4 weeks, men scored 3.9 (SD 1.1) and women 3.3. (SD 1.1). Subjects who scored high (scores 4 and 5) in this question, also scored high in neurogenic symptoms (M-W-test, $P = 0.000$) and in the disability index (M-W-test, $P = 0.002$).

A total of 23 of 37 men (62%) and 7 of 14 women (50%) had significant disc degeneration (*i.e.*, Grade V

Table 1. Characteristics of Patients

	Men	Women
No. (%) of subjects	37 (73)	14 (27)
Age (years) (± SD)	54 (8.1)	59 (7.3)
Smokers (%)	21 (57)	4 (29)
Body mass index (kg/m^2) (± SD)	25 (2.7)	27 (4.2)
Serum total cholesterol (mmol/L) (± SD)	5.7 (1.1)	5.6 (0.9)
Serum LDL-cholesterol (mmol/L) (± SD)	3.7 (1.0)	3.4 (0.7)

LDL = low density lipoprotein.

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Table 2. Men and Women Showing Significant (Grade V) Disc Degeneration in MR Images and Occluded Lumbar/Middle Sacral Arteries in MR Aortography

MR Imaging	Men (N = 37) [no. (%)]	Women (N = 14) [no. (%)]	Significance
Disc degeneration at L1–L4 (%)	8 (22)	2 (14)	NS
Disc degeneration at L4–L5 (%)	11 (30)	3 (21)	NS
Disc degeneration at LV–S1 (%)	14 (38)	6 (43)	NS
Disc degeneration at any lumbar level (%)	23 (62)	7 (50)	NS
MR aortography			
One or more lumbar arteries missing (%)	11 (30)	5 (36)	NS
Middle sacral artery missing (%)	27 (73)	11 (79)	NS
Any lumbar/middle sacral artery missing (%)	29 (78)	11 (79)	NS

NS = nonsignificant.

degeneration) on at least one lumbar level. Disc degeneration was most common at LV–S1 (Table 2). Disc degeneration was not related to neurogenic symptoms (M-W-test, $P = 0.12$), disability index (M-W-test, $P = 0.07$), or severe pain (scores 4 and 5) ($\div^2 = 0.02$; Fisher's exact 1.00).

Eleven of 37 men (30%) and 5 of 14 women (36%) had one or more occluded lumbar arteries. When occlusion of the middle sacral artery was included, 29 men (78%) and 11 women (77%) had occluded arteries (Table 2). The prevalence of occluded arteries in these patients was 2.5 times higher than in subjects of corresponding age group in a Finnish unselected necropsy material.[22] The middle sacral artery was most often occluded, followed by the fourth lumbar arteries. Since only few subjects showed occlusion of upper lumbar arteries, we were not able to assess correlation between disc degeneration and occluded lumbar arteries at the matching levels. Disc degeneration at any lumbar level and occlusion of any lumbar and/or middle sacral artery showed a positive correlation ($\div^2 = 4.8$; Fisher's exact $P = 0.035$). Patients with occluded lumbar/middle sacral arteries did not scored higher in neurogenic symptoms (M-W-test, $P = 0.87$), disability index (M-W-test, $P = 0.61$), or severe pain ($\div^2 = 0.23$, $P = 0.73$) than those without.

Serum cholesterol level was above normal (*i.e.*, ≥5.0 mmol/L) in 40 of 51 subjects (78%), and LDL cholesterol was above normal (*i.e.*, ≥3 mmol/L) in 39 of the subjects (76%). Patients with above normal LDL cholesterol scored higher in neurogenic symptoms (M-W-test, $P = 0.031$) and complained more often severe pain (scores 4 and 5) ($\div^2 = 4.3$, Fisher's exact 0.049) than patients with normal LDL cholesterol. Patients with occluded lumbar/middle sacral arteries had more often above normal cholesterol ($\div^2 = 6.8$, Fisher's exact 0.02) and above normal LDL cholesterol ($\div^2 = 4.3$, Fisher's exact 0.046) than those without.

Body mass index was not associated with serum cholesterol levels, occluded lumbar or middle sacral arteries, or disc degeneration. Smokers did not have more severe disc degeneration but showed a slight tendency, although not statistically significant, to have more occluded lumbar/middle sacral arteries (*t* test, $P = 0.065$) than nonsmokers.

■ Discussion

Our study showed that patients with long-term lower back pain often have occluded lumbar/middle sacral arteries and that occlusion of these arteries is associated with disc degeneration. Furthermore, patients with high LDL cholesterol complained more severe back symptoms than those with normal value. These findings support previous studies that occlusion of lumbar/middle sacral arteries is associated with lower back pain and disc degeneration,[1–3,23] and that occlusion of these arteries may be due to atherosclerosis.[13,24]

Occlusion of lumbar and middle sacral arteries results from atheromatous lesions in the posterior wall of the aorta, building up in the ostia of branching arteries.[13,24] Growing plaques, in turn, cause stenosis and gradual occlusion of arteries. We compared our findings with those of a necropsy study on unselected Finnish subjects (140 subjects; age range, 16–89 years, mean age, 47 years).[22] In the age groups best matching our material (45–59 and 60–89 years; mean age, 59 years; in our study, mean age, 56 years), 15% of the subjects had occluded lumbar arteries (in our study, 31%), 23% showed occluded middle sacral artery (in our study, 74%), and 31% had occluded lumbar and/or middle sacral arteries (in our study, 78%). Thus, in the present study, the percentage of patients with occluded arteries greatly exceeded the expected prevalence in the Finnish population.

Because it is not possible to perform MR angiographies on cadavers, findings between MR studies on patients and postmortem studies on cadavers are not totally comparable. Studies comparing conventional clinical angiographies and postmortem studies have indicated that the postmortem angiographic study has higher specificity and sensitivity than the clinical study and, thus, it is regarded as the reference standard.[25,26] In another study, testing the validity of MR aortography in evaluating the status of lumbar arteries, MR aortographies were compared to conventional digital substraction aortographies. A good agreement was found between the investigation methods, especially as far as occlusion of the arteries was concerned.[27] Most of the cases with disagreement concerned the stenosis of lumbar arteries (which were not analyzed in our study). A good compat-

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ibility between conventional clinical and postmortem angiographies as well as between conventional and MR angiographies indicates that a good agreement has to exist also between postmortem and MR angiographies, making comparisons between postmortem study and our study reliable.

Disc degeneration and occlusion of the lumbar/middle sacral arteries were read from the different set of MR images by separate readers, increasing the reliability of the study. To assess disc degeneration, we selected the Pfirrmann *et al* grading system, since it is, as far as we know, the only standardized assessment of MRI disc degeneration in English literature.[20] In the Pfirrmann et al study, 21% of the subjects had Grade V disc degeneration, in ours 59% had this degree of degeneration. The subjects in the first mentioned study were younger (mean age 40 years) and had no back symptoms, the facts that probably explain the difference in the prevalence.

The association of high serum cholesterol and high LDL cholesterol levels with the occlusion of the lumbar/middle sacral arteries was expected. Cholesterol, and especially the LDL ('bad') cholesterol, are well-known risk factors for atheromatous disease.[28] The associations between high LDL cholesterol and neurogenic symptoms, disability index, and severe pain may occur through atheromatous plaques clogging arteries and diminishing blood flow to pain sensitive structures. However, the association is not clear, and high LDL cholesterol may also be associated with other disorders, which are the actual causes of back symptoms. Hemingway *et al* found that low apo AI and triglycerides (also risk factors for atherothrombotic disease) were associated with sickness absence because of back pain, whereas serum total cholesterol and high LDL cholesterol showed no correlation.[4] In another study, by Welin *et al*, no correlation was found between serum cholesterol or triglyceride levels and back pain.[5] We were not able to find any study on serum lipids and disc degeneration.

Occlusion of the lumbar/middle sacral arteries was not associated with severe back symptoms. If arterial obstruction occurs slowly, it may pass with mild symptoms, or no symptoms at all, whereas a more speedy process may cause more severe symptoms. Gradual occlusion of an artery may allow time for tissues to adapt to diminished blood supply and to develop collateral pathways. Although the blood supply of the lumbar spine is principally segmental, segmental arteries are, however, connected by several small anastomoses.[7,29,30] Obliteration of lumbar/middle sacral arteries is often followed by the widening of these anastomoses, and also by the formation of new arterial pathways.[29,30] However, blood supplied via anastomoses cannot totally compensate for a normal vascular supply,[31] with consequential hypoxia and tissue dysfunction. These changes in turn may lead to deterioration and atrophy of the structures involved.[32] The intervertebral disc with its precarious nutrient supply may be one of the first structures to suffer damage from insufficient blood flow, thus linking occluded arteries with disc degeneration. A few cases of sudden occlusion of the lumbar artery have been published,[33–36] indicating that abrupt arterial occlusion may cause severe back pain. In our material, patients with high LDL cholesterol may have had more accelerated occlusion of lumbar/middle sacral arteries, thus connecting high LDL level to more severe back symptoms.

Occluded arteries, as well as, high LDL cholesterol are indicators of atheromatous disease. In the feeding arteries of the lumbar spine, atheromatous lesions decrease blood flow and nutrient supply to the lumbar spine and its surrounding structures and may contribute to disc degeneration and lower back symptoms.

■ Key Points

- Patients with long-term nonspecific lower back pain frequently have occluded lumbar/middle sacral arteries.
- Occlusion of lumbar/middle sacral arteries is associated with disc degeneration.
- High serum LDL cholesterol level is associated with severe neurogenic symptoms and back pain.

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