EXTENDED REPORTS

Prevalence of stenotic changes in arteries supplying the lumbar spine. A postmortem angiographic study on 140 subjects

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Abstract

Objectives—To study the prevalence of arterial diseases in the arteries supplying the lumbar spine and their relation to other vascular diseases, as well as to chronic low back pain.

Methods—Five pairs of the lumbar arteries and the middle sacral artery were evaluated from 140 postmortem aortograms, performed in connection with routine medicolegal necropsies on subjects ranging from 16 to 89 years of age. For information about low back pain history, a close relative of each of the deceased was interviewed two to four weeks after the necropsy.

Results—Twenty one (22%) men and nine (20%) women had occluded arteries, and an additional 33 (35%) men and 17 (38%) women had narrowed arteries. The mean age for men with occluded or narrowed arteries, or both, was 50 years and for women 59 years. Most of the stenotic changes were seen at the orifices or in the first part of the arteries. The middle sacral artery was most often affected, followed by the fourth lumbar arteries. The number of collateral arteries increased with occluded (p <0.001) and narrowed arteries (p = 0.001). Stenotic lumbar/middle sacral arteries were found, on average, five years earlier than atherosclerosis of the coronary arteries. Subjects with one or more occluded/narrowed arteries were 8.5 times more likely to have suffered from chronic (that is, three months or longer) low back pain at some time during their life than were those without such findings (odds ratio adjusted for age and sex 8.5; 95% confidence intervals 2.9, 24; p <0.001).

Conclusions—The study shows that the lumbar and middle sacral arteries frequently become obliterated by atheromatous lesions during adult life, and that obliteration of these arteries is more common in subjects with a history of chronic back pain than in those without.

(*Ann Rheum Dis* 1997;**56**:591–595)

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Four pairs of lumbar arteries supply the first through the fourth lumbar segments. The fifth lumbar segment is supplied by the small fifth lumbar arteries, which are branches of the middle sacral artery, and also by tributaries of the iliolumbar arteries branching from the internal iliac arteries.[1] The four upper pairs of the lumbar arteries and the middle sacral artery originate in the posterior wall of the abdominal aorta. Compared with the rest of the aorta, this part of the aorta, especially at the orifices of branching arteries, often shows the earliest and most pronounced involvement of atherosclerosis.[2-5] The aim of this study was to assess the prevalence of arterial diseases in the arteries that supply the lumbar spine and their relation to other cardiovascular diseases, as well as to low back pain.

Methods

One hundred and forty postmortem lumbar aortographies were performed on 95 men and 45 women, aged from 16 to 89 years (mean 47). The subjects had not undergone back surgery (had no trace of an incision on the back), and had not been killed in a traffic accident. In other respects the material consisted of unselected medicolegal necropsy cases. The cause of death was drug or alcohol overdose, or suicide in 58 (41%) cases, coronary artery disease in 40 (29%), other vascular disease in 21 (15%), and a variety of single diseases in 21 (15%).

To visualise the lumbosacral arterial systems, the aorta was transected at the mid-thoracic level, cannulated with a mouthpiece, and its anterior and lateral branches and the external iliac arteries clamped. The internal iliac arteries were clamped beyond the origin of the iliolumbar arteries. The contrast medium consisted of liquid silicone rubber (Silicon Kautschuk RTV-Vergussmasse K, Wacker Chemie, Munich, Germany) made radio opaque with 20% lead oxide and then mixed with 2% solidifier (Haerter T, Wacker Chemie). This material was injected into the aorta under 120–150 mm Hg of pressure. Pressure was maintained for two hours to allow the mixture to solidify. This technique of injection has been found to fill arteries as narrow as 0.1 mm in

Figure 1   Aortogram of a 52 year old man without low back symptoms showing four pairs of lumbar arteries and the middle sacral artery (white arrow). Contrast medium has been removed from the aorta to make the first parts of the lumbar arteries visible.
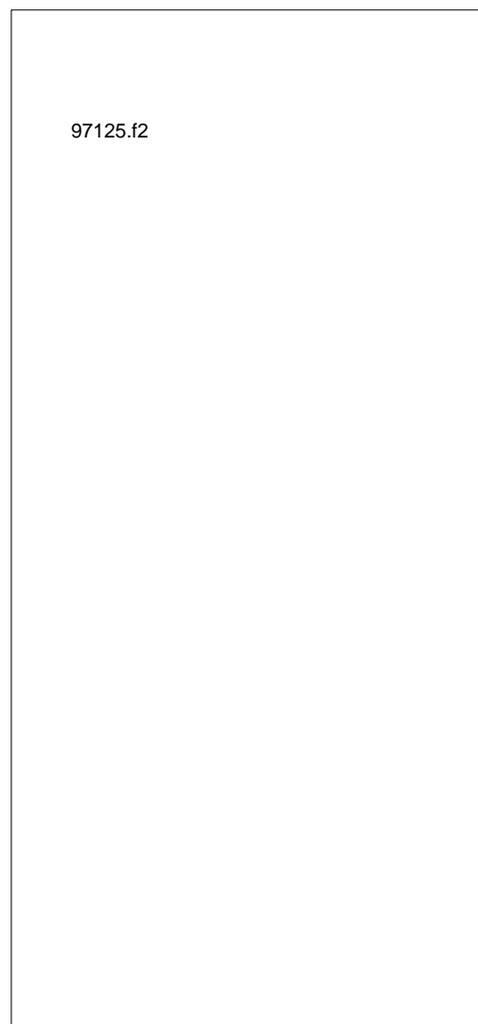

Figure 2   Aortogram of a 49 year old woman who had suffered from chronic low back pain. Note narrowed right L1 artery (thick arrow), missing right L4 artery (thin arrow), and collateral artery (C) running from right L3 artery down to L4 level and feeding retrogradely the distal part of the L4 artery.

diameter. The technique of angiography has been described previously.[6] A conventional Siemens fullwave *x* ray machine was used with Agfa-Gevaert Scopix CR3B film (Agfa Gevaert, Mortsel, Belgium). Radiographs were taken from an anteroposterior and lateral view using a distance of 100 cm, 40–55 kV, and 300 mAs. When the contrast medium was solidified, it was removed from the aorta. Thereafter the radiographs were taken to visualise also the first parts of the lumbar arteries, situated behind the aorta (figs 1 and 2).

The four pairs of lumbar arteries and the middle sacral artery were evaluated on the radiograms 4 cm peripherally from the orifices. Occlusions, as well as diffuse or segmental narrowings in the diameter of the vessels by 50% or more, were recorded. An artery showing diffuse narrowness was compared with its contralateral vessel, if normal, or to the next artery above. The middle sacral artery was compared with the right fourth lumbar artery. Major collateral arteries—that is, anastomosing arteries that were clearly visible and run

between vertebral segments (fig 2), on both sides of the vertebral column—were also recorded. Although the iliolumbar arteries were visible in all angiograms, their branches to the sacrum and to the lowest lumbar vertebra were tiny and variable and thus, the arteries were omitted from analysis. However, the collaterals formed by these arteries with the lumbar arteries were recorded.

Angiograms were read blindly without knowledge of demographic features or necropsy findings of the subjects. Two investigators, one of them a radiologist with special knowledge of angiographies, evaluated the first 60 radiograms. Correlation coefficients indicating the interobserver agreement of the two evaluations were 0.94 for the missing arteries, 0.90 for the narrowed arteries, and 0.73 for the collaterals. The angiograms, whose evaluations yielded disagreement on the number of missing/narrowed arteries or collaterals, were re-read jointly to reach agreement. The series was later completed by another 80 angiograms, read blindly by the author alone.

Table 1   Characteristics of subjects with and without radiological findings in lumbar and middle sacral arteries

	Normal arteries		Occluded and/or narrowed arteries	
	Men	*Women*	*Men*	*Women*
Subjects (n)	41	19	54	26
Age, years (range)	39 (17-72)★	37 (16-65)★	50 (23-76)★	59 (25-89)★
Body mass index, kg/m2 (SD)	25 (3.8)	24 (6.2)	25 (4.8)	25 (4.8)
Hypertension (%)	4 (10)	2 (11)	3 (6)	7 (26)
Diabetes (%)	5 (12)	0 (0)	5 (9)	5 (19)
Coronary atherosclerosis (%)	12 (29)	2 (11)	22 (41)	9 (33)
Chronic low back pain (%)†	5 (13)	0 (0)	21 (47)	14 (67)

★ p < 0.001 for difference between sexes with normal arteries and occluded/narrowed arteries (*t* test). † Information on back pain history received from 123 subjects.

The findings in the later series were consistent with those of the preliminary series.[7]

For information about low back pain history, a close relative of each of the deceased was interviewed after all the investigations concerning the cause of death were completed. During the interviews, held over the telephone or during a personal appointment, questions about the back pain history of the deceased were asked after a general discussion of the cause of death. The relatives were asked: (1) had the person complained of low back pain at any time during his or her life, and if so, (2) did it cause any notable difficulties in daily life, for example, in moving or doing housework, and (3) how long did the low back pain period last? According to their back pain history, the subjects were classified into two groups; (1) those with chronic back pain—that is, low back pain that had caused notable difficulties in daily life and had lasted at least three months at some point during their life and (2) those without such symptoms—that is, no back pain or back pain not exceeding three months. Back pain history was received from 123 subjects (84 men and 39 women). In three cases no near relative was found and in another 14 cases the relative(s) of the deceased stated that they were not aware of the person's lifetime back symptoms.

Information about age, weight, height, and atherosclerosis of the coronary arteries was available from the records of the necropsy, and information on hypertension and diabetes from the death certificates listing both necropsy and clinical diagnoses. Atherosclerosis of coronary arteries was recorded as present if it was included in the list of necropsy diagnoses, indicating that pronounced atheromatous lesions had been found in the coronary arteries. Less pronounced findings in the coronary arteries, which are extremely common in necropsy material in Finland, were left outside the analysis.

Statistical analyses were performed using SAS.[8] Categorical data were analysed by using Spearman's rank correlation procedure. Comparison of two groups were performed with use of the two sample Student *t* test. To test relations between findings in the lumbar arteries, cardiovascular diseases, and back pain, odds ratios and test based confidence intervals were assessed using logistic regression with adjustment for age and sex.

Results

Twenty one (22%) men and nine (20%) women had occluded lumbar or middle sacral arteries, or both, and an additional 33 (35%) men and 17 (38%) women had narrowed arteries. Men showed stenotic changes at a younger age than did women: the mean age for men with occluded or narrowed arteries, or both, was 50 years and for women 59 years (p <0.001) (table 1). The youngest subject to show an occluded artery was a 23 year old man with an occluded middle sacral artery. The number of occluded and narrowed arteries increased with age, as did the number of major collateral arteries (table 2). The middle sacral artery was more often occluded or narrowed than any of the lumbar arteries. Of the radiographic findings in the lumbar arteries, 62% occurred in the fourth lumbar arteries, and the rest of the findings were evenly distributed in the first through third lumbar arteries.

Collateral arteries were more common in subjects with occluded (Spearman rank correlation; *r* = 0.455; p <0.001) and narrowed arteries (*r* = 0.275; p = 0.001) than in those with normal arteries. Of the subjects with occluded/narrowed arteries, 67 (84%) showed major collateral arteries running parallel to vertebral column, while 13 (16%) did not. However, even in the last mentioned subjects, filling of a few small arteries in the region of the obliterated artery was seen. Arterial filling in these cases probably occurred via small and possibly numerous collateral pathways.

Findings typical of atherosclerosis, such as tortuosity and poststenotic dilatations were frequently seen in arteries with narrowings. Most of the segmental narrowings were seen at the orifices or in the first part of the arteries. The abdominal aortas, though not systematically analysed (because of staining from contrast medium), exhibited atheromatous changes ranging from fatty streaks to fibrous plaques and extensive areas of complicated lesions, such as ulceration and haemorrhage. In cases with occluded artery(ies), fibrous or

Table 2   Radiological findings by age groups

	≤ 30 years	31–44 years	45–59 years	≥ 60 years
Sex (males/females)	23/9	25/9	26/10	21/17
Subjects (n) (%)				
One or more occluded L1–L4 lumbar arteries	1 (3)	3 (8)	3 (8)	8 (21)
One or more narrowed L1–L4 lumbar arteries★	1 (3)	2 (6)	5 (14)	7 (18)
Occluded middle sacral artery	1 (3)	3 (9)	4 (11)	13 (34)
Narrowed middle sacral artery	4 (12)	12 (35)	14 (39)	10 (26)
Any occluded/narrowed L1–L4 lumbar and/or middle sacral artery	7 (22)	17 (50)	25 (69)	31 (82)
Major collateral arteries	7 (12)	15 (44)	18 (50)	27 (71)

† Excluding those with occluded arteries.

Figure 3   Anteriorly split abdominal aorta of a 56 year old man showing normal orifices of the third lumbar arteries (thick arrow) and stenotic orifices of the first, second, and fourth lumbar arteries (thin arrows). The orifice of the middle sacral artery (lowest arrow) is totally occluded by a fibrous lesion around it.

other advanced lesions were frequently found around the supposed orifice of the artery(ies). The extent and stage of aortic atherosclerosis were variable. In some cases atheromatous lesions in the intima of the aorta were extensive and advanced without obliteration of any of the arteries, while in others with less extensive lesions, a fibrous plaque locating around the orifice of an artery severely obstructed its lumen (fig 3). Stenotic lumbar/middle sacral arteries were found, on average, five years earlier than was pronounced atherosclerosis of the coronary arteries (mean (SD) ages 53 (16) and 58 (12) respectively). In logistic regression, after adjustment for age and sex, association between angiographic findings in the lumbar/middle sacral arteries and coronary artery atherosclerosis was positive but not significant (odds ratio 3.1; 95% confidence intervals 0.8, 12; p = 0.10). Furthermore, no statistically significant correlation was found between stenotic lumbar/middle sacral arteries and hypertension (odds ratio 1.7; 95% confidence intervals 0.7, 5.8; p = 0.38), and diabetes (odds ratio 1.2; 95% confidence intervals 0.3, 4.0; p = 0.83).

Of 123 subjects with back pain history, 40 (26 men, 14 women; mean age 53, range 31–75

years) had suffered from chronic low back pain at some time during their life, whereas 83 (58 men, 25 women; mean age 40, range 16–76 years) had not. Fourteen men and seven women with positive back pain history had complained of back symptoms during the last months before death, while others had had back trouble years or decades earlier and had not complained of any back related symptoms during their last months. In logistic regression, after adjustment for age and sex, chronic back pain at any time during life was 8.5 times more common in those with occluded/narrowed arteries than in those without such findings (odds ratio 8.5; 95% confidence intervals 2.9, 24; p <0.001).

Discussion

The prevalence of stenotic changes in the arteries supplying the lumbar spine increased with age and was higher in subjects with a history of chronic back pain than in those without such history. Stenotic changes in the lumbar and middle sacral arteries occurred several years earlier than did significant atheromatous lesions in the coronary arteries. Associations between findings in the lumbar/middle sacral arteries and other cardiovascular diseases were statistically non-significant.

Because the walls of the arteries were not examined histologically, we do not know whether some of the radiographic findings resulted from congenital anomalies. Several aspects in the study, however, suggest that most of the findings are caused by atherosclerosis: (1) macroscopic atheromatous lesions in the area of the supposed orifices in the aorta frequently co-existed with missing arteries; (2) narrowed arteries often showed radiological findings typical of atherosclerosis, such as tortuosity and poststenotic dilatations; (3) most of the missing and narrowed arteries originated in the lower part of the aorta—that is, in that part of the aorta that shows the earliest and most pronounced atheromatous lesions[4 5 9]; and (4) the young subjects showed few missing or narrow arteries, indicating that congenital anomalies are rare, and that obliteration of these arteries usually occurs during adult life.

The blood supply of the lumbar spine is principally segmental; segmental arteries are, however, connected by several small anastomoses in the longitudinal ligaments, paraspinal muscles, spinal cord, and dura.[1 10 11] Obliteration or stenosis of lumbar arteries may be followed by the widening of these anastomoses, and also by the formation of new arterial pathways.[9 11] In this study the number of collateral arteries was also found to increase with the number of stenotic arteries. Depending on a person's ability to develop collateral pathways, local ischaemia resulting from an obliterated artery may have several different outcomes: collateral arteries may open at the pace of arterial obliteration and prevent ischaemic symptoms to emerge; development of an efficient collateral network may take more time than the occlusion of an artery and ischaemic symptoms will occur for some time; or no effi-

cient collateral circulation develops and structures, such as nerve roots, vertebral bodies, and muscles suffer from ischaemic symptoms and gradually atrophy. In these cases, atrophy of the muscles together with physical inactivity may with time decrease nutrient demand and limit symptoms. In general, collateral circulation develops slowly and does not totally compensate for a normal vascular supply.[9] [12]

In this study the back pain histories relied almost totally on information obtained from family members of the deceased. In only a few cases was it possible to check the history from the medical records of the subject. In a study of a corresponding type, Videman and coworkers[13] found that a high proportion of families were able to provide information on the deceased subject's lifetime history of back pain. Low back pain, which causes difficulties in daily life for a lengthy time, probably does not pass unnoticed. At interviews, most of the relatives were well aware of the back problem, if a person had one, and of approximately how long it had lasted. Because of the large number of suicides and deaths from alcohol misuse, the mean age of the subjects in this study was quite low and, thus, the material is not comparable to other studies of lifetime prevalence of low back pain.

The material, consisting of medicolegal necropsy cases, is a selected sample of the population. However, forensic necropsy material is regarded as one of the best possible cross sectional samples of a population for the study of atherosclerosis.[14] Postmortem angiography is considered optimal for postmortem determination of arterial stenosis,[15] and compared with clinical angiography, it is regarded as the reference standard.[16–18] In Finland, medical necropsy is performed on 14% of all deaths, and medicolegal necropsy on an additional 17%. Of the subjects having died under the age of 65 years in 1992, 61% had a necropsy, of which 17% were medical and 44% were medicolegal.[19]

Prevalence of atherosclerosis is increased in groups with lower social status than in higher status groups.[20] It is also well known that subjects with low social status are over-represented in forensic necropsy material, especially as far as intoxication, suicide, or homicide is concerned. Information about social background, received from the police, was regarded as insufficient to permit categorising subjects into different social or occupational classes. The below average social status of the overall material might have increased, to some extent, the prevalence of atherosclerosis.

The study shows that blood supply to the lumbar region is frequently compromised in middle aged and older subjects, especially in those with a history of chronic low back pain. However, as this study is cross sectional it leaves the cause and effect relation unclear; and we do not know whether stenotic lumbar/middle sacral arteries are the true cause for low back pain or whether atherosclerosis in these arteries increases with other disorders, which are the actual causes of back symptoms. In any event, stenotic and occluded arteries, by decreasing nutrient supply and hampering repair process, contribute to and modify symptoms caused by possible other disorders.

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