Cohort Assessment

Clinical and Radiological Characteristics of Concomitant Peripheral Arterial Obstructive Disease in Patients with Lumbar Spinal Stenosis

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Background: Intermittent claudication is a typical symptom of lumbar spinal stenosis (LSS) and peripheral arterial obstructive disease (PAD). Because both LSS and PAD are predominantly associated with degenerative conditions, concomitant conditions are not uncommon. However, few reports of the demographic, clinical, and radiological characteristics of concomitant LSS and PAD (LSSPAD) have been published.

Objective: To identify the demographic, clinical, and radiological risk factors for concomitant PAD in LSS.

Study Design: A retrospective matched-control study.

Methods: This study involved a retrospective cohort of 43 consecutive patients with LSSPAD and a control cohort of 45 age- and gender-matched patients diagnosed with LSS without PAD. Each patient in both groups underwent plain lumbar radiographs, magnetic resonance imaging of the lumbar spine, and ankle-brachial index (ABI) measurement. Demographic and clinical parameters were obtained. The abdominal aorta calcification score (AACS) was evaluated on the lateral lumbar radiographs. Computed tomographic angiography (CTA) of the lower limb was performed to confirm PAD.

Results: The mean age of the LSSPAD group was 67.7 ± 10.7 years (52 – 88 years). The prevalence of diabetes mellitus (DM) was significantly higher in the LSSPAD group than in the LSS group (P = 0.022). The mean ABI was 0.71 ± 0.22 (0.32 – 0.91) for the LSSPAD group and 0.96 ± 0.18 (0.83 – 1.10) for LSS group (P < 0.001). The prevalence of aortic calcification was significantly higher in the LSSPAD group than in the LSS group (P < 0.001). The mean AACS was 10.2 ± 3.2 (2 – 18) for the LSSPAD group and 3.4 ± 4.1 (0 – 14) for the LSS group (P < 0.001).

Limitations: Retrospective design.

Conclusion: We found that concomitant PAD in patients with LSS is associated with old age, DM, the presence of aortic calcification, and ABI < 0.9. When these risk factors exist, further work up is needed to exclude the concomitant PAD.

Key words: Claudication, lumbar spinal stenosis, peripheral arterial obstructive disease, aortic calcification, ankle-brachial index

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Because claudication is created by both lumbar spinal stenosis (LSS) and peripheral arterial obstructive disease (PAD) (1,2), several discriminative characteristics associated with spinal or vascular pathologies are recognized by physicians (3-6). Vascular claudication of PAD typically occurs after activity or walking for a distance with resultant vascular insufficiency in which the muscular demand of oxygen outweighs the supply (5). Resting from activity even in a standing position may help to relieve the symptoms.

On the other hand, neurogenic claudication of LSS is associated with activity and spinal position. Narrowing of the spinal canal and neural foramen is aggravated by standing and relieved by sitting and flexion (7); thus, neurogenic claudication may be relieved by sitting down or leaning over.

However, making a differential diagnosis in the clinical setting is often difficult due to subjective symptoms and atypical signs (8). Examination of the peripheral pulse is still the major tool for excluding PAD, but the positive predictive values are unsatisfactory (9). In addition, the comprehensive diagnostic step considering both concomitant PAD and LSS has not been established well. Although the ankle-brachial index (ABI) is a useful screening test for excluding PAD with high sensitivity and specificity (10), concomitant affections of LSS and PAD are not uncommon because they are associated with many of the same degenerative conditions (4,8,11,12).

Although a minority of patients with vascular claudication (0.25 – 0.45 per 1,000 people/year) develop symptoms of critical leg ischemia (rest pain and skin ulceration) (13,14), early identification of PAD is essential because it allows for preventive measures that can decrease the predicted mortality and morbidity (15,16). Reports of the clinical and radiological characteristics of coexistent vascular and spinal claudication are limited. The aim of this study was to identify the clinical and radiological risk factors of concomitant PAD in patients with LSS.

Methods

We retrospectively reviewed a cohort of 43 consecutive patients who were identified as concomitant LSS and PAD (LSSPAD) and an age- and gender-matched control cohort of 45 patients who were diagnosed with LSS without PAD. The LSSPAD subjects were recruited through the department of orthopedic surgery in a tertiary hospital between October 2007 and September 2011. The control cohort was set up on a random basis among our database of 288 LSS patients during the inclusion period of the LSSPAD. The common symptom for inclusion in both groups was intermittent claudication with walking difficulty for more than 5 minutes over a period of 6 months. Patients with established PAD evidenced by gangrenous limbs, ulcerous feet, or a previous diagnosis of PAD, and patients with a history of significant leg trauma were excluded. Each patient in both groups underwent plain lumbar radiographs, magnetic resonance imaging (MRI) of the lumbar spine, and ABI measurement. Computed tomographic angiography (CTA) of the lower limb was performed to confirm PAD. The diagnosis of LSSPAD was determined by consensus opinion of a foot and ankle surgeon (S.H.H.) and a spine surgeon (C.H.J.). Our institutional review board approved the current study.

Risk Factor Assessment for LSSPAD

Demographic information on each patient's age, gender, weight, height, body mass index (BMI), smoking habit, and medical conditions (diabetes mellitus [DM], hypertension, or cardiovascular disease) were obtained from the medical records. According to the American Diabetes Association criteria (17), patients with a fasting glucose level of $\geq$ 7.0 mmol/L (126 mg/dL) or under antidiabetic treatment were categorized as having DM. Patients were considered to be hypertensive if they had a blood pressure (BP) of $\geq$ 140/90 mm Hg, or 130/80 mm Hg in those with DM or chronic kidney disease, or were being treated with antihypertensive medication (18). Current smokers and recent smokers (quit within 6 months) were considered to have the risk factor for smoking.

Back pain, leg pain, neurological deficits, decreased pedal pulsation, atrophic skin changes, bilateral symptoms of claudication, and claudication provoked by walking uphill or downhill were analyzed as clinical parameters. Pain was scored using a visual analogue scale (VAS) on a 100 mm horizontal line, where 0 represented no pain and 100 represented the maximum imaginable pain. Motor power was evaluated with the Medical Research Council (MRC) scale by manual muscle testing as follows: 0, no contraction; 1, flicker or trace contraction; 2, active movement with gravity eliminated; 3, active movement against gravity; 4, active movement against gravity and resistance; 5, normal power (19). Motor power of the lower extremity < grade 4 was regarded as motor weakness. The dorsalis pedis arterial pulse was palpated lateral to the extensor hallucis longus tendon on the dorsal surface of the foot, distal to the dorsal most prominence of the navicular bone. Atrophic skin changes were assessed by observing for hair loss, smooth shiny skin, or thinning of skin.

The ABI was measured by a trained technician using a Nicolet VasoGuard® (Nicolet Vascular Inc., Madison, WI) using photoplethysmography. The patients were sent to a separate room for the ABI measurements under optimal conditions. Photoplethysmographic sensors were attached to the tips of the greater toes, and cuffs were placed on the patient's arms and lower calves (just above the ankles). Systolic blood pressures from the

bilateral upper and lower extremities were measured simultaneously, and the bilateral great toe pulses were captured to compute the ABI. The ABI was considered to be abnormal when the lower value was < 0.9.

The abdominal aorta calcification score (AACS), ranging from 0 to 24, was evaluated on the lateral lumbar radiographs using a methodology previously described by Kauppila et al (20). Briefly, calcific deposits in the abdominal aorta from L1 to L4 were assessed separately for the posterior and anterior walls of the aorta. Lesions were graded as follows: 0, no aortic calcific deposits; 1, small scattered calcific deposits filling less than one-third of the longitudinal wall of the aorta; 2, calcific deposits of one-third or more, but less than two-thirds of the longitudinal wall of the aorta, and calcifications present in front of L3 and L4 vertebrae; and 3, calcific deposits of two-thirds or more of the longitudinal wall of the aorta calcified. The scores of the individual aortic segments for both the posterior and anterior walls (8 segments) were then summed (Fig. 1).

The severity of central canal stenosis was evaluated based on grading of dural sac morphology as determined by the cerebrospinal fluid (CSF) and epidural fat signal on T2-weighted axial MRI as described by Schizas et al (21) as follows: minor (some CSF in the dural sac presenting a grainy appearance to the dural sac), moderate (no rootlets can be recognized, but the epidural fat is present posteriorly), or severe D (no rootlets and no epidural fat can be recognized).

The severity of foraminal stenosis was evaluated by observing the epidural fat obliteration in the intervertebral foramen on T1-weighted sagittal MRI as described by Wildermuth et al (Table 1) (22). Using CTA images, the extent of PAD was categorized as mild (50 – 74%), moderate (75 – 94%), and severe (≥ 95%), and the location of stenosis was recorded as iliac, femoral, popliteal, or below the trifurcation. All radiological measurements were performed by one radiologist and 2 orthopedic surgeons, 3 times each, and the mean value of the measurements was identified.

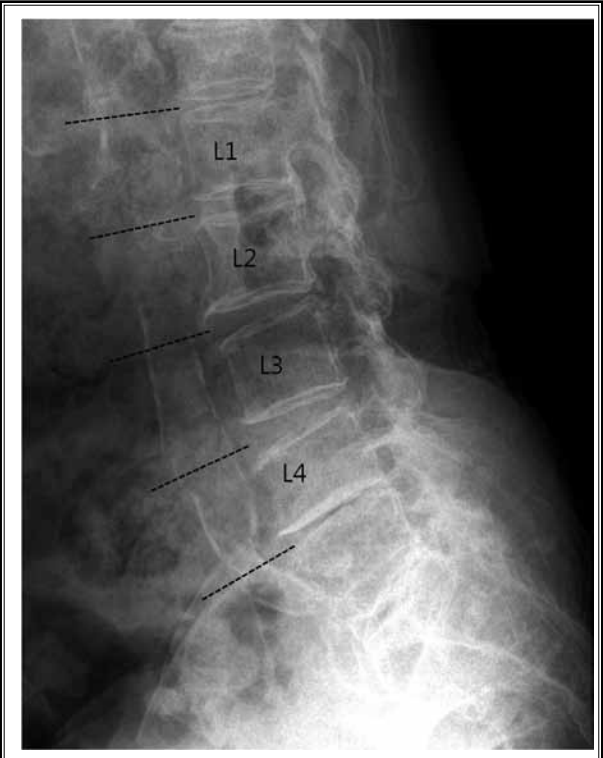

Fig. 1. *Calculation of the abdominal aorta calcification score. Calcific deposits in the abdominal aorta from L1 to L4 were scored separately for the posterior and anterior walls of the aorta, and were summed.*

Table 1. *Wildermuth's MR grading system for lumbar foraminal stenosis*

Grade	
0	Normal foramina [normal dorsolateral border of the intervertebral disk and normal form at the foraminal epidural fat (oval or inverted pear shape)]
1	Slight foraminal stenosis and deformity of the epidural fat, with the remaining fat still completely surrounding the exiting nerve root
2	Marked foraminal stenosis, with epidural fat only partially surrounding the nerve root
3	Advanced stenosis with obliteration of the epidural fat

Statistical Analysis

Descriptive statistics are summarized as frequencies and percentages for categorical variables, and as means and standard deviations for continuous variables. A Student t-test, a chi-square test, and Wilcoxon's signed rank test were used to compare each demographic and measured parameter between the 2 groups. Clinical and radiological risk factors were examined using univariate and multivariate logistic regression analysis, and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Variables with a P value < 0.10 on univariate analysis were included in the multivariate logistic regression analysis. Statistical analysis was carried out using SPSS version 12.0 software (SPSS Inc., Chicago, IL). A *P* value of < 0.05 was considered to indicate statistical significance.

Results

Demographics of LSSPAD and LSS

The demographics of the 43 LSSPAD patients and 45 LSS patients are shown in Table 2. The mean patient age was 67.7 ± 10.7 years (52 – 88) in the LSSPAD group and 67.6 ± 8.3 years (45 – 86) in the LSS group (P = 0.964). There were 24 (55.8%) men in LSSPAD group and 25 (55.6%) men in the LSS group (P = 0.981). The prevalence of DM was significantly higher in the LSSPAD group than in the LSS group (P = 0.022). There were no differences in body weight (P = 0.634), height (P = 0.338), BMI (P = 0.313), smoking (P = 0.480), hypertension (P = 0.496), and cardiovascular disease (P = 0.165) between the 2 groups.

Clinical and Radiological Characteristics of LSSPAD and LSS

Table 3 shows the radiological and clinical characteristics of the LSSPAD and LSS groups. The mean ABI was 0.71 ± 0.22 (0.32 – 0.91) for LSSPAD legs and 0.96 ± 0.18 (0.83 – 1.10) for LSS legs; these values were significantly different (P < 0.001). The prevalence of ABI < 0.9 was significantly higher in the LSSPAD group than in the LSS group (P < 0.001). The mean AACS was 10.2 ± 3.2 (2 – 18) for LSSPAD and 3.4 ± 4.1 (0 – 14) for LSS; these values were significantly different (P < 0.001). The prevalence of aortic calcification was significantly higher in the LSSPAD group than in the LSS group (P < 0.001).

There were no differences in the severity of lower back pain (P = 0.369), leg pain (P = 0.341), bilateral leg symptoms (P = 0.276), claudication provoked by walk-

Table 2. *Demographics of LSSPAD and LSS**

Variables	LSSPAD (N=43)	LSS (N=45)	P
Age	67.7 ± 10.7	67.6 ± 8.3	0.964
Male sex	24 (55.8)	25 (55.6)	0.981
Weight (kg)	66.4 ± 10.9	66.7 ± 12.2	0.634
Height (cm)	163.6 ± 8.5	165.7 ± 9.2	0.338
BMI (m/kg2)	24.4 ± 3.5	23.7 ± 2.5	0.313
Smoking	16 (37.2)	18 (40.0)	0.480
Diabetes mellitus	31 (72.1)	22 (48.9)	0.022
Hypertension	23 (53.5)	23 (51.1)	0.496
Cardiovascular disease	18 (41.9)	14 (31.1)	0.165

Note: BMI = body mass index
*Unless otherwise noted, data are numbers of subjects and percentages in parentheses.

Table 3. *Clinical and radiological characteristics of LSSPAD and LSS**

Variables	LSSPAD (N=43)	LSS (N=45)	P
Clinical findings			
Back pain (VAS)	37.9±18.8	34.1±15.4	0.369
Leg pain			
Severity (VAS)	50.9±14.7	47.6±14.5	0.341
Bilateral symptom	33 (76.7)	29 (64.4)	0.276
Provoked to walk uphill	23 (53.5)	24 (53.3)	0.543
Provoked to walk downhill	13 (30.2)	16 (35.6)	0.419
Decreased power	14 (32.6)	14 (31.1)	0.539
Decreased sensation	26 (60.5)	24 (53.3)	0.323
Decreased pedal pulse	9 (20.9)	7 (15.6)	0.347
Atrophic skin change	7 (16.3)	4 (8.9)	0.629
ABI measurement			
< 0.9	38 (88.4)	14 (31.1)	< 0.001
Mean ABI	0.71 ± 0.22	0.96 ± 0.18	< 0.001
Aortic calcification			
Prevalence	38 (88.4)	16 (35.6)	<0.001
Mean AACS	10.2 ± 3.2	3.4 ± 4.1	< 0.001
MRI			
Central stenosis Minor	7 (16.3)	8 (17.8)	0.484
Moderate	26 (60.5)	23 (51.1)	
Severe	10 (23.3)	14 (31.1)	
Foraminal stenosis Slight	23 (53.4)	24 (53.3)	0.681
Marked	12 (27.9)	10 (22.2)	
Advanced	8 (18.6)	11 (24.4)	
CTA			
Severity Mild	8 (18.7)	-	
Moderate	24 (55.8)	-	
Severe	11 (25.6)	-	
Location Iliac	5 (11.6)	-	
Femoral	15 (34.9)	-	
Popliteal	5 (11.6)	-	
Below TF	5 (11.6)	-	
Multiple	13 (30.2)	-	

Note: ABI = ankle-brachial index ; VAS = visual analogue scale; CTA = CT angiography
*Unless otherwise noted, data are numbers of subjects and percentages in parentheses.

ing uphill (P = 0.543), and claudication provoked by walking downhill (P = 0.419) between the 2 groups. Motor weakness of the lower leg (P = 0.539), decreased sensation (P = 0.323), decreased pedal pulse (P = 0.347), and atrophic skin changes (P = 0.629) were not different between the 2 groups. There was no difference between the 2 groups in the radiological severity of lumbar spinal stenosis at either the central region (P = 0.484) or foraminal region (P = 0.681).

Multivariate Logistic Regression for Concomitant PAD in LSS Patients (Table 4)

Multivariate analysis results demonstrated that the ABI < 0.9 (OR, 8.129; 95% CI, 2.117 – 31.216) was the most significant risk factor, followed by presence of aortic calcification (OR, 5.419; 95% CI, 1.313 – 22.369) and DM (OR, 1.676; 95% CI, 1.180 – 9.526).

Table 4. Multivariate logistic regression for concomitant PAD in LSS patients

	Odds ratio (95% confidence interval)	*P*
ABI < 0.9	8.129 (2.117-31.216)	0.002
Presence of aortic calcification	5.419 (1.313-22.369)	0.019
DM	1.676 (1.180-9.526)	0.045

Discussion

Because both LSS and PAD are usually associated with degenerative conditions, their prevalence is increasing with the aging of the population. A recent epidemiologic study reported that as much as 20% of the population older than 75 years of age have PAD, but it is undiagnosed in more than half of them (9). The majority of patients with intermittent claudication make an initial visit for leg pain; however, a comprehensive diagnostic protocol for patients with both PAD and LSS has not been established. The clinical characteristics of the leg pain and an examination of the peripheral pulse are still the major tools for screening PAD, but the diagnostic validity is low (8,9). Plain radiographs of the lumbar spine are frequently performed first to identify spinal lesions. If degenerative findings are evident on plain radiographs, an initial impression of LSS can be obtained. This prejudiced impression may derived from the high prevalence of spinal degenerative conditions in general population (23). Additional imaging tests including spinal CT or MRI can then be considered to clarify the details of the spinal pathologic structures. If these additional imaging studies show positive findings of LSS, the initial impression of LSS can be verified and the possibility of PAD can be discarded. However, the specificity of these imaging studies is not so high to confirm the diagnosis of LSS. On the other hand, if the imaging study results are ambiguous for LSS, the consideration of LSS is abandoned and switched to PAD.

Because a concomitant neurological or orthopedic condition is common in PAD patients (8), exclusion of PAD among LSS patients is usually more a concern to primary care physicians than exclusion of LSS among PAD patients. Thus, our study was designed to compare the radiological and clinical characteristics of LSSPAD and LSS without PAD. This study involved 43 patients with LSSPAD and a control group of 45 patients with LSS, which is the largest series to the authors' knowledge. The inclusion of LSSPAD was discussed by both a foot and ankle surgeon and a spine surgeon, and a consensus opinion was obtained. Moreover, radiologic evidence was obtained with CTA and MRI. Therefore, the validity of the present study is greater than previous reports.

Our results show that a low ABI, the presence of aortic calcification, and having DM are significant risk factors for LSSPAD. The ABI is currently the most common clinical diagnostic test for PAD, because it is simple, noninvasive, inexpensive, objective, reliable, and specific (24). However, its sensitivity is unreliable. Although a sensitivity of > 90% for the ABI was reported in established PAD populations (25,26), it was significantly lower in other population studies. Carter (27) reported that the ABI was abnormal in 80% of patients with severe arterial stenosis on angiography, while it was abnormal in only 50% of patients with mild stenosis. Williams et al (28) reported a sensitivity of 38% in patients with DM neuropathy, and Feigelson et al (29) found a sensitivity of 28.4% in patients with atypical symptoms or signs. One explanation for the inaccurate ABI is that the systolic BP cannot be eliminated by the inflation of an air-filled BP cuff in patients with noncompressible calcified arteries, mildly obstructed arteries, and atypical presentations (25). The process of stiffening of the arteries has been shown to start from around the first or second decade of life in healthy individuals, and it can be accelerated by medical conditions including renal disease and DM. The stiffer the artery, the faster the pulse will travel through it to the periphery (30). Thus, we recommend performing CTA to confirm the diagnosis of PAD, because it is a more reliable and valid confirmative test (31).

Abdominal aorta calcification is closely associated with subclinical cardiovascular diseases and PAD (32).

Although the validity of AACS has not been elucidated, we found that it provides a simple, fast, low-cost, and reliable assessment for discriminating LSSPAD from LSS.

DM is a multi-organ disorder affecting many types of connective tissue, including the skeletal and vascular systems (33). Moreover, diabetic neuropathy is one of the conditions commonly considered as a differential diagnosis of PAD or LSS. Therefore, physicians should consider the probability of LSSPAD beyond simple dichotomous discrimination of either PAD or LSS.

This study had several limitations. The retrospective design, which involved possible data associated with the use of medical records, miscoding, and a lack of clinical information, may have caused uncertainty in the results. Lack of data on epidemiology, natural history, and response to medical treatment also reduced its clinical significance. Moreover, other variables including psychosocial or physiologic factors such as social activity, depressive mood, osteoarthritis, and neuropathic pain were not considered as demographic risk factors. These may have affected the patients' symptoms and signs.

Conclusion

We found that concomitant PAD in patients with LSS is associated with old age, DM, the presence of aortic calcification, and ABI < 0.9. When these risk factors exist, further work up is needed to exclude the concomitant PAD.

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