Measurement of exercise tolerance on the treadmill in patients with symptomatic lumbar spinal stenosis: a useful indicator of functional status and surgical outcome

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A prospective study of patients with neurogenic claudication and lumbar spinal stenosis was undertaken to determine whether measurement of exercise tolerance on the treadmill would be useful in defining baseline functional status and response to surgical treatment. Twenty patients with an average age of 73 years, all of whom had intractable neurogenic claudication and radiographically confirmed severe lumbar spinal stenosis, were studied. Lumbar decompressive laminectomy was performed in all patients. Preoperatively and 2 months postoperatively, quantitative assessment of ambulation was conducted on a treadmill at 0° ramp incline at two different speeds: 1.2 mph and the patient’s preferred walking speed. The following information was recorded: time to first symptoms, time to severe symptoms, and nature of symptoms (leg pain, back pain, or generalized fatigue). The examination was stopped after 15 minutes or at the onset of severe symptoms.

In the preoperative 1.2-mph trial, the mean time to first symptoms was 2.68 minutes (median 1.31) and the mean time to severe symptoms was 5.47 minutes (median 3.42). In the postoperative trial at the same speed, 13 patients (65%) were able to walk symptom free for 15 minutes. The mean time to first symptoms was 11.12 minutes (median 15) and the mean time to severe symptoms was 11.81 minutes (median 15). Similar findings were recorded in the preferred walking–speed trials. There were no complications from the treadmill testing procedure. These findings indicate that exercise stress testing on a treadmill is a safe, easily administered, and quantifiable means of assessing baseline functional status and outcome following laminectomy in patients with symptomatic lumbar spinal stenosis.

KEY WORDS • decompressive lumbar laminectomy • exercise stress testing • lumbar spinal stenosis • neurogenic claudication • treadmill

Decompressive laminectomy for acquired degenerative lumbar spinal stenosis is one of the most commonly performed neurosurgical procedures. Although surgical results are generally reported to be good, objective measures of outcome are limited. Return to work, a commonly used indicator of outcome following spinal surgery for other diagnoses, is not as useful in lumbar spinal stenosis because most patients with this condition are retired. Thus the surgeon must often base the assessment of a patient’s postoperative progress on limited and subjective outcome data, such as that obtained from a patient interview or questionnaire.

To develop more objective outcome measures, exercise stress testing on a treadmill was considered for neurosurgical application. Long used by cardiologists in the assessment of coronary artery disease, treadmill testing has several features that make it potentially attractive to the clinician evaluating patients with lumbar spinal stenosis. First, walking readily precipitates the symptoms for which the patient has sought medical attention. Second, the examination has an excellent safety record and is easy to administer. Third, the results are more quantifiable than information obtained by a patient questionnaire or interview. Therefore, a prospective study was undertaken to determine whether measurement of exercise tolerance on a treadmill would be useful in assessing preoperative functional status and postoperative progress in patients who undergo decompressive laminectomy for lumbar spinal stenosis.

Clinical Material and Methods

Patient Population

Twenty patients (15 men and five women) with an average age of 73 years (range 53 to 83 years) were studied. All had intractable neurogenic claudication and radiographically confirmed severe lumbar spinal stenosis.
Lumbar decompressive laminectomy was performed in all patients. After surgery, patients were instructed to progressively increase ambulation. Formal physical therapy was employed as needed. Patients with congenital lumbar canal stenosis and lumbar disc herniation were excluded, as were individuals requiring simultaneous fusion.

Treadmill Protocol

Preoperatively and 2 months postoperatively, quantitative assessment of ambulation was conducted on a treadmill at 0° ramp incline. Two trials were conducted, the first at 1.2 mph and the second at the patient’s preferred walking speed. A brief rest was permitted between trials to allow symptoms to return to baseline levels. The following information was recorded: time to first symptoms, time to severe symptoms, and nature of symptoms (leg pain, back pain, generalized fatigue, other). A time of zero was recorded when symptoms were present at onset. The examination was stopped after 15 minutes or at the onset of severe symptoms. Severe symptoms were defined as the level of discomfort that would make patients stop their activities in usual life situations. Patients were instructed to walk with an upright posture. They were not permitted to lean forward or hold onto the handrails during the examination. Treadmill testing was conducted in the Department of Physical Medicine and Rehabilitation by a physical therapist (J.L.V.) and a physiatrist (M.C.M.) independent of the surgical team. All patients were screened for medical conditions that would make treadmill testing unsafe (Table 1).

Statistical Methods

Differences between preoperative and postoperative results were assessed using the Wilcoxon signed-rank test, which is a nonparametric analog to the Student’s paired t-test. All tests were two sided and p values less than 0.05 were considered statistically significant.

Results

The treadmill testing procedure was easily administered, and there were no complications or patient complaints.

In the preoperative 1.2-mph trial, the mean time to first symptoms was 2.68 minutes (median 1.31) and the mean time to severe symptoms was 5.47 minutes (median 3.42). Postoperatively, the mean time to first symptoms was 11.12 minutes (median 15) and the mean time to severe symptoms was 11.81 minutes (median 15). Thirteen patients were postoperatively able to walk symptom free for 15 minutes. The average improvement in time to first symptoms was 8.44 minutes (median 9.14). This was statistically significant (p < 0.001). Data from the 1.2-mph trial are displayed in Figs. 1 and 2.

In the preoperative preferred walking–speed trial, the mean time to first symptoms was 2.03 minutes (median 1.82) and the mean time to severe symptoms was 4.49 minutes (median 4.0). Postoperatively, the mean time to first symptoms was 9.43 minutes (median 15), and the mean time to severe symptoms was 10.15 minutes (median 15). Two patients did not attempt the preferred walking–speed trial because of generalized fatigue following completion of the 1.2-mph trial. Improvement in time to first symptoms and time to severe symptoms was statistically significant in both trials.

In the postoperative 1.2-mph trial, seven patients were unable to complete 15 minutes on the treadmill. Three had to stop because of generalized fatigue and deconditioning, one because of hip pain due to degenerative joint disease, and one because of knee pain due to degenerative joint disease. One patient was unable to complete the test because of difficulty walking due to an old fusion of the left knee; his neurogenic claudication was improved, however. The seventh patient reported persistent radicular leg pain that was suggestive of unrelieved nerve root compression.

Treadmill testing data were useful in guiding the further management of these seven patients. The three individuals with fatigue/deconditioning were referred for an active rehabilitation program. The two patients with hip and knee disease were referred for orthopedic evaluation of the symptomatic joint. The individual with the surgically fused left knee had experienced excellent relief of his neurogenic claudication symptoms, and it was believed that his limited exercise tolerance simply reflected the gait limitations imposed by a completely immobile knee joint. No further investigation was required. The patient with persistent radicular leg pain underwent further spinal imaging and was considered for additional decompressive surgery.

Discussion

The pathophysiology, clinical features, and management of lumbar spinal stenosis have been reviewed in...
Treadmill tolerance in lumbar spinal stenosis

Fig. 2. Bar graph showing time to severe symptoms, 1.2-mph trial, before and after surgery.

Outcome after decompressive lumbar laminectomy is generally thought to be satisfactory and success rates of 64% to 95% have been reported. In these series, outcome was assessed by means of a patient interview or questionnaire. In two of these studies an assessment of walking capacity was made on the basis of data obtained from a patient questionnaire, but none used any formal perioperative functional testing. Most patients with lumbar spinal stenosis are retired; therefore, work status usually cannot be used as an indicator of postoperative progress. In addition, there are increasing pressures from third-party payers and various other agencies for more objective outcome measurements in all aspects of medicine and surgery. With these issues in mind, efforts were made to develop a more objective means of evaluating this common spinal disorder and the response to surgical treatment.

Exercise Stress Testing

Standardized exercise protocols to assess cardiopulmonary function were first developed in 1929. Since that time, exercise stress testing has come to be widely used, particularly in the evaluation of patients with coronary artery disease. The Bruce protocol is popular, and an extensive literature has been developed. Other cardiovascular treadmill tests include those of Naughton, Cornell, Balke-Ware, and Weber.

Functional testing has also been used in the diagnostic evaluation of patients with neurogenic claudication. First reported by van Gelderen in 1948, functional status has been assessed using a bicycle, a horizontal treadmill or other level surface, and a treadmill with a downhill slope. Dong and Porter reported a study comparing walking and bicycling tolerance. Treadmill testing has also been reported to have utility in screening for lumbar instability.

Neurosurgical Application of Treadmill Testing

The cardiovascular protocols were considered for neurosurgical application; however, some drawbacks were noted. First, the starting speed for the standard Bruce protocol is 1.7 mph, which proved to be too fast for spinal stenosis patients. Second, each of these protocols involves progressive increases in speed and ramp incline during the examination, thus further emphasizing cardiopulmonary function over neuromusculoskeletal performance.

Preliminary experience with the Bruce protocol in the present study showed that patients developed cardiopulmonary symptoms and had to stop walking before they developed leg pain, thus rendering the test ineffective from a neurosurgical standpoint. It was thought that neurogenic claudication would be better demonstrated by ambulation at a slower, constant speed on a level surface. Accordingly, the treadmill parameters of a walking speed of 1.2 mph and a ramp incline of 0° were adopted.

The end point of 15 minutes of ambulation was chosen because no new information was provided by extending the test to a greater length of time. In preliminary studies, postoperative patients who walked for longer periods of time (up to 30 minutes) did not develop neurological symptoms with prolonged walking. It is possible that increasing the treadmill speed or ramp incline could have elicited symptoms in patients who were asymptomatic after 15 minutes. However, our experience indicated that the capacity to ambulate symptom free for 15 minutes after decompressive laminectomy was a reasonable indicator of a good result.

It is important that patients maintain an upright posture while walking on the treadmill. There is a tendency to flex forward at the waist if the handrails are used for support. This may open up the lumbar canal and relieve neurogenic claudication, thus rendering the test inaccurate. Therefore, patients were instructed to walk with an upright posture and not use the handrails during the treadmill procedure.

Safety Issues

Treadmill testing in cardiac patients has an excellent safety record. In nonselected patient populations the mortality is less than 0.01% and morbidity is less than 0.05%. The risk of complications in patients without cardiopulmonary symptoms is extremely low. The contraindications to the procedure are medical, primarily cardiovascular (Table 1). In the present study the treadmill examination was well tolerated, and there were no complications or patient complaints.

Interpretation of Test Results

The main benefit of the preoperative treadmill examination was to provide an objective measure of baseline functional status prior to laminectomy. Although not used for this purpose in the present study, an unexpectedly good performance on the preoperative test could be used to support a decision to defer surgery.

The postoperative 1.2-mph and preferred walking-speed trials both documented substantial improvement in most patients, and findings were virtually identical in the two trials. For future applications of treadmill testing, it appears that only one trial is needed and that either walking speed can be used.

The postoperative study results also proved very useful in guiding the further evaluation of patients who were unable to complete the examination. The most common cause for postoperative treadmill “failure” was generalized deconditioning and fatigue resulting from prolonged physical inactivity prior to surgery. These patients reported generalized fatigue but no leg pain; they were encouraged to pursue an active rehabilitation program. One
patient with persistent radicular pain was easily identified by treadmill testing, and his subsequent care was focused on the management of unrelieved nerve root compression. By contrast, the two patients with hip and knee pain were shown to be free of radicular pain with treadmill testing, and their subsequent management was directed toward orthopedic evaluation of the symptomatic joint.

Future Applications

In our institution, treadmill testing has become a standard part of the perioperative assessment of patients with lumbar spinal stenosis. In the future this tool will be used in long-term follow up of the postoperative patient and in assessment of the efficacy of nonsurgical treatment.

Conclusions

Measurement of exercise tolerance on a treadmill is a safe, easily administered, quantifiable means of assessing functional status in patients with lumbar spinal stenosis and neurogenic claudication. Test results are useful in assessing outcome following lumbar decompressive laminectomy and in guiding the subsequent management of patients with residual symptoms.

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References


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