Current Pain and Headache Reports (2019) 23: 32
https://doi.org/10.1007/s11916-019-0769-x

NEUROPATHIC PAIN (A ABD-ELSAYED, SECTION EDITOR)

Neurogenic Claudication: a Review of Current Understanding and Treatment Options

Shadi Messiah[1] · Antony R. Tharian[1,2] · Kenneth D. Candido[1,2,3] · Nebojsa Nick Knezevic[1,2,3]

Published online: 19 March 2019

Abstract

Purpose of Review With an aging population and increased prevalence of the disease, we set out to evaluate the validity of current diagnostic criteria for neurogenic claudication as well as the efficacy of the treatment options for the main cause, lumbar spinal stenosis (LSS).

Recent Findings Epidural steroid injections (ESI) were most efficacious when the injectate is a steroid combined with lidocaine or lidocaine only. There are promising results regarding the efficacy of the minimally invasive lumbar decompression (MILD) procedure as well as interspinous process spacers (IPS) compared to surgical alternatives. Spinal cord stimulators are gaining ground as an effective alternative to surgery in patients with lumbar spinal stenosis that is not responsive to conservative measures or epidural injections.

Summary We found that there continues to be a lack of consensus on the diagnostic criteria, management, and treatment options for patients with LSS. The Delphi consensus is the most current recommendation to assist clinicians with making the diagnosis. Physical therapy, NSAIDs, gabapentin, and other conservative therapy measures are unproven in providing long-lasting relief. In patients with radicular symptoms, an ESI may be indicated when a combination of lidocaine with steroids is used or using lidocaine alone. In addition, there is not enough high-quality evidence to make a recommendation regarding the use of MILD versus interspinous spacers for neurogenic claudication. There remains a need for high-quality evidence regarding the efficacy of different conservative treatments, interventional procedures, and surgical outcomes in patients with neurogenic claudication in LSS.

Keywords Neurogenic claudication · Lumbar spinal stenosis · Back pain · Epidural injection · Interventional procedures

Introduction

Intermittent claudication is the onset of lower extremity pain that is exacerbated by exercise or activity and which is relieved with rest [1]. The causes for claudication can be of vascular versus neurogenic etiologies. Vascular causes of such pain include peripheral arterial disease (PAD) which most commonly presents with calf claudication. In PAD, pain is caused by restriction in arterial blood flow due to atherosclerotic plaques that form over time. This restriction of flow leads to claudication that limits walking distances and quality of life [2]. Symptoms of PAD are specific to the location of arterial blockage. Aortoiliac disease can present with buttock and hip pain [3]. The presentation of the triad: claudication, impotence, and diminished peripheral pulses due to aortoiliac occlusion is also known as Leriche syndrome [4]. Patients can also present with thigh pain due to common femoral artery occlusion. Calf pain is the most common presentation, which can be due to superficial femoral artery or popliteal artery stenosis [5, 6]. In addition to an arterial etiology, claudication can also be due to venous insufficiency in which case the pain will be present when standing and sitting with legs in a dependent position [7].

Radicular pain is usually the hallmark of lumbar spinal stenosis (LSS). When it is worsened with ambulation and relieved with rest, it is referred to as neurogenic claudication.

This article is part of the Topical Collection on *Neuropathic Pain*

✉ Nebojsa Nick Knezevic
nick.knezevic@gmail.com

[1] Department of Anesthesiology, Advocate Illinois Masonic Medical Center, 836 W. Wellington Ave. Suite 4815, Chicago, IL 60657, USA

[2] Department of Anesthesiology, University of Illinois, Chicago, IL, USA

[3] Department of Surgery, University of Illinois, Chicago, IL, USA

The pain associated with neurogenic claudication is typically exacerbated by a position of spinal extension and relieved with spinal flexion [8]. Spinal stenosis is most commonly seen in the lumbar region, followed by cervical spine, and rarely, the thoracic spine [9]. Patients with lumbar spinal stenosis can have stenosis in the central spinal canal, lateral recess, or neural foramen [10].

Spinal stenosis is generally considered to be a disease of older adults. Some estimates show that approximately 90% of the US population will present with complaints of low back pain at some point in their life [11]. Some estimate the prevalence of lumbar spinal stenosis to be around 47% in people over the age of 60 [12]. Lumbar spinal stenosis remains the most common cause for lumbar spine decompression surgery in patients over the age of 65 [13].

Presentation

In the patient presenting with intermittent claudication, it is important to differentiate between vascular and neurogenic causes. Table 1 highlights some of the differences between these two diagnostic considerations. Patients with PAD typically describe their pain as feeling of cramping, or tightness, while patients with spinal stenosis often describe their pain as numbness or tingling. Both will have pain that is exacerbated by walking and which is relieved with rest. A proper vascular exam and evaluation of distal pulses is useful in making this distinction. Neurogenic claudication is exacerbated with spinal extension and improves with spinal flexion. This is also labeled as a positive "shopping cart sign." A study of cadaveric spines showed that spines in flexion had a 12% greater foraminal cross-sectional area while spines in extension had a 15% smaller cross-sectional area compared to spines in neutral orientation. Extended spines also had 33.3% nerve root compression [14]. Evidence has shown that reduction in the cross-sectional area of the spinal canal leads to further compression on the venules around the spinal nerve roots [15]. This results in engorgement and ischemia of the nerve roots. Flexion relieves that ischemia and therefore the pain. These patients also find it easier to walk uphill because of spinal flexion while patients with PAD still exhibit claudication symptoms.

In 1995, Katz et al. performed a study investigating the reliability of history and physical examination of patients with lumbar spinal stenosis [16]. The study included 93 patients with ages between 40 and 91 with a mean age of 65.3 years. The majority of the subjects were Caucasian (83%) and females (69%). The subjects all had complaints of low back pain. The study analyzed the results of a standardized history and physical examination and compared it with expert physician assessment of these patients along with operative reports and imaging results that were available. They found that the most specific history finding for LSS was pain relief when seated (93% specificity). On the other hand, a wide-based gait and a positive Romberg test were the most specific physical exam findings with 97 and 91% specificity, respectively.

Etiology

There are two broad categories of spinal stenosis: congenital and acquired [17]. Congenital causes of spinal stenosis can include dwarfism such as achondroplasia or spondyloepiphyseal dysplasias. Also, dystosis multiplex as seen in mucopolysaccharidoses such as Morquio's syndrome or Hurler's disease are congenital conditions associated with spinal stenosis [18, 19]. Mucopolysaccharidoses are lysosomal enzyme deficiency leading to deposition of glycosaminoglycans in cartilage and soft tissues [20]. Other congenital conditions for spinal stenosis include spinal dysraphisms such as spina bifida, spondylolisthesis, and myelomeningoceles [21].

However, the most common causes of lumbar spinal stenosis are acquired [17]. They include degenerative disc disease leading to bulging of the discs, degenerative osteoarthritis leading to facet arthropathy and hypertrophy of the ligamentum flavum, which contributes to central spinal canal stenosis and neural foraminal narrowing.

Table 1 Comparison of vascular versus neurogenic claudication

	Vascular	Neurogenic
Pain location	Calves	Back, buttocks, thighs
Pain type	Cramping, dull, tightness	Radicular, sharp, numbness, tingling
Exacerbating factors	Activity, walking	Walking/standing erect, spinal extension
Alleviating factors	Rest	Spinal flexion
Onset of relief	Immediate	Within minutes
Imaging	Angiogram	MRI of lumbar spine
Exam	Diminished pulses	Positive straight leg test

Diagnosis

Since lumbar spinal stenosis was first described in 1954 by Dr. Verbiest, there remained a disagreement and lack of standardized clinical criteria for the diagnosis of the condition [22]. The fact that there is a wide range of disease presentations adds to the complexity of the diagnostic process. There is also a lack of specificity of objective criteria. For example, a patient with signs and symptoms of LSS can undergo an MRI or CT of lumbar spine to confirm the presence of the anatomic pathology. However, while imaging can be helpful, it is not always specific, especially considering more dynamic pathologies that cannot always be demonstrated on imaging [23].

In light of this, Tomkins-Lane et al. took on the challenge of performing a Delphi study to come up with a consensus on "which factors obtained from the history are most important in the diagnosis of LSS." [24••]. They began by forming the Taskforce on Diagnosis and Management of Lumbar Spinal Stenosis during the 2012 meeting of the International Society for the Study of the Lumbar Spine (ISSLS). The Taskforce included a multidisciplinary team of researchers, neurosurgeons, orthopedic surgeons, vascular surgeons, radiologists, physical therapists, and chiropractors from around the world. The study was done in three phases. In phase 1, the Taskforce discussed 14 questions and chose which questions should be included in the Delphi study. In phase 2, an online survey was created which was emailed to all ISSLS members. These results were reviewed in an in-person meeting of the Taskforce and after revisions were made, the final version of the survey was distributed to multiple international spine societies. The Taskforce received 279 surveys from professionals in 29 different countries with a mean of 19 years of experience (± 12). In phase 3, the Taskforce met again to form a final list of questions based on the latest results of the survey.

The study found that clinicians could become 80% certain of their diagnosis by relying upon 6 questions. The Delphi consensus then chose the top 7 historical questions which are the following:

1. Does the patient have leg or buttock pain while walking?
2. Does the patient flex forward to relieve symptoms?
3. Does the patient feel relief when using a shopping cart or bicycle?
4. Does the patient have motor or sensory disturbance while walking?
5. Are pulses in the foot present and symmetric?
6. Does the patient have lower extremity weakness?
7. Does the patient have low back pain? [24••].

These 7 questions from the Delphi consensus are a useful tool to be used as a guide in the diagnostic process. In addition, it is important to recognize that treatments and certain injections are also used as therapeutic and diagnostic tools. The study was concluded in 2015 recognizing that they were not able to account for diagnostic tests. The Taskforce started another Delphi study, which is currently underway, to examine other diagnostic studies and attempt to arrive to a consensus regarding additional objective studies.

Treatment Options

Treatment options for patients can be divided into conservative, minimally invasive, and surgical. Conservative measures include mainstays such as physical therapy, NSAIDs, and other pharmacological agents.

Tran et al. performed a review of nonsurgical treatment options of lumbar spinal stenosis in 2010 [25]. Their assessment included randomized controlled trials (RCTs) of nonsurgical treatments from 1950 to 2010 and yielded 13 randomized controlled trials. Six of those randomized controlled trials were regarding pharmacological therapy: 3 on calcitonin, 1 on gabapentin, 1 on limaprost, and 1 on methylcobalamin. Eskola et al. conducted a double-blind, crossover, randomized controlled trial on 39 patients with lumbar spinal stenosis [26]. They compared subcutaneous calcitonin to placebo and found statistically significant differences in reduction of pain in the calcitonin group. However, pain relief only lasted 3 months and no benefit was seen at 1 year. Podichetty et al. and Tafazal et al. both performed double-blind RCTs on intranasal calcitonin. They recruited 47 patients to compare daily intranasal calcitonin with placebo for 6 weeks and found no differences between the two groups in terms of pain relief or improvement in walking ability [27]. Tafazal et al. recruited 37 patients for a 4-week comparison with a placebo and also found no differences [28]. A 2011 meta-analysis by Podichetty et al. that reviewed four papers from 1966 to 2008 found that calcitonin did not provide a benefit over placebo in pain relief [29].

A Cochrane review by Ammendolia et al., in 2013, reviewed 56 articles and selected 21 randomized controlled trials to be included in the review [30]. The trials included a total of 1851 subjects equally distributed between male and female (926 and 925, respectively) with an average age of 50. The study considered six trials regarding calcitonin. Three of them were the ones already discussed above. Those 6 studies included 231 subjects and showed that calcitonin did not confer a benefit over paracetamol or a placebo. According to the criteria of their Cochran review, they found these studies to be of "very low quality."

The study also looked at trials on other oral medications. Matsudaira et al. conducted a trial of 79 subjects between the ages of 50 and 85 [31]. The subjects were randomized to take either limaprost (prostaglandin E1 derivative) or etodolac (NSAID) for 8 weeks. The limaprost group had improvement in walking distances and pain compared to etodolac. The Cochrane review found this evidence to be of "low quality."

The trial by Yaski et al. conducted on 55 subjects randomized to two groups [32]. One group was treated with standard treatment, which included exercise, lumbosacral brace use, and NSAIDs. The other received gabapentin in addition to the standard treatment. The review found "very low quality" evidence supporting improvement in pain and walking distance in the gabapentin group compared to the control. There was also a trial by Waikakul et al. evaluating the efficacy of methylcobalamin in a single-blind group that included 152 patients with average age of 67 (55–85 age range) [33]. They were randomized to two groups: 85 in the control and 70 in the methylcobalamin group. The review determined that the study provided low-quality evidence that methylcobalamin improved walking distances in the treatment group.

The Cochrane review also evaluated four trials on the effects of physical therapy and exercise on patients with lumbar spinal stenosis. Goren et al. conducted a RCT on 45 patients with an average age of 53.2 (range 25–82) that were randomized to 1 of 3 groups: ultrasound plus exercise, sham ultrasound plus exercise, and no exercise [34]. The study found that the exercise group had improved pain scores and functionality after 3 weeks and the ultrasound group had less use of analgesics. Pua et al. found that walking on a treadmill and use of a stationary bike are no different in terms of efficacy [35]. This study included 68 patients with an average age of 58 years and followed the patients for 6 weeks. Koc et al. randomized 29 patients between 3 groups: inpatient physical therapy, epidural steroid injection, or home exercise plus diclofenac (control) [36]. The trial showed that inpatient physical therapy was more effective than at home exercise plus diclofenac. Lastly, Whitman et al. conducted a trial of 58 patients that were randomized to one of two 6-week physical therapy programs [37]. The patients showed minor improvements in pain with the combination of physical therapy, exercise, and unweighted treadmill walking. The Cochrane review determined that Goren and Pua et al. produced "low quality" evidence, while Koc and Whitman et al. produced "very low quality" evidence.

Most patients that present to a pain management practice have exhausted conservative therapy options. At that point, those patients can benefit from minimally invasive and non-surgical treatment options depending on their specific diagnosis. We created the algorithm in Fig. 1 as a suggested guide of a step-by-step sequence of treatment for neurogenic claudication.

Epidural Steroid Injections (ESI)

Patients with spinal stenosis typically have the classic symptoms of neurogenic claudication described earlier. They describe their symptoms as burning, tingling, and "sharp needles" like. The pain usually radiates to below the knee and they will complain of their leg symptoms more than their back discomfort. Since this is usually due to degenerative disc disease and compression of nerve roots, it is best addressed with epidural steroid injections delivered and targeted to the affected nerve root(s) [38]. These injections can include medications such as steroids, local anesthetics, or both. Steroids work by decreasing the inflammation surrounding the spinal cord and nerve roots [38]. Local anesthetics work by decreasing the transmission of nociceptive pain and increasing blood flow [38]. The effectiveness of ESI and particularly the steroid component of the injection has been in question.

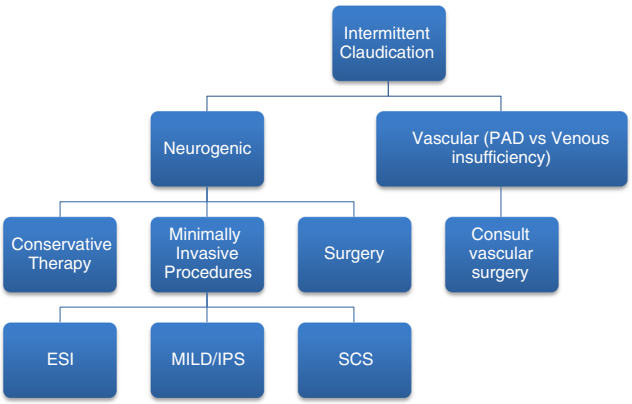

Fig. 1 Treatment options for claudication. ESI, epidural steroid injection; MILD, minimally invasive lumbar decompression; IPS, interspinous process spacer; SCS, spinal cord stimulator; PAD, peripheral arterial disease

In a 2012 randomized controlled trial by Manchikanti et al. that used the numeric rating scale (NRS) and the Oswestry disability index 2.0 (ODI) to compare the efficacy of steroids versus local anesthetic alone in providing long-lasting pain relief in patients receiving caudal epidural injections [39], they had 100 patients randomized between two groups. In group 1, patients received caudal epidural injections of lidocaine 0.5% alone, and in group 2, patients received 9 mL of lidocaine and 1 mL of steroid (6 mg betamethasone). They found significant pain relief (defined as greater than 50% reduction in pain) in 70% of patients and reduction in ODI scores in 67% of patient in group 1 compared to 77% of patients having pain relief and 75% of patient having reduction in ODI scores in group 2 [40]. Group 1 received on average 3.8 (± 1.4) procedures per year and group 2 received 3.6 (± 1.1). They also noted that patients in the group 2 (steroid group) had greater pain relief with the first two procedures compared to patients in group 1. Based on the evidence available, they were not able to formulate a recommendation regarding the use of a local anesthetic with or without a steroid. Of note, in another RCT, the same institution compared the efficacy of pain relief of epidural adhesiolysis versus caudal epidural injections [41]. They randomly assigned 100 patients to either group 1 (25 patients) which received caudal epidural injections with local anesthetic/0.9% saline/betamethasone, and group 2 (25 patients) who

underwent percutaneous adhesiolysis with a directed injection of lidocaine/10% saline/betamethasone. Using the same metrics, they reported significant pain relief (> 50%) in 76% of patients receiving adhesiolysis compared to only 4% in the active control group (caudal epidural injection).

We reviewed a 2016 meta-analysis by Manchikanti et al. that evaluated the efficacy of different epidural injections. They evaluated trials comparing epidural injections containing steroids with saline, local anesthetics alone, and steroids with local anesthetics. They selected 39 trials that met their inclusion criteria. They listed four trials investigating epidural steroid injections with saline. There were three trials (131 patients) showing that epidural steroid injections with saline were ineffective in short- and long-term follow-ups. There was one trial with 50 patients that showed short-term (3–6 week) pain relief in patients undergoing epidural steroid injections with saline. The short-term effect was shown in three other trials with 173 patients that received ESI with bupivacaine. However, there were two other trials with 142 patients that reported a lack of efficacy of ESI with bupivacaine. In addition, five studies with 763 patients compared injections containing steroids plus saline and steroids plus bupivacaine. Steroids plus saline were administered to 232 patients and steroids plus bupivacaine were given to 531. Meta-analysis of the data showed no differences between the placebo and either group. Based on that evidence, they concluded that steroid injections, when combined with saline or bupivacaine, were ineffective [42•]. Instead, they found that lidocaine with steroids or lidocaine alone had statistically significant efficacy on radiculopathy in spinal stenosis [42•].

Minimally Invasive Lumbar Decompression (MILD)

Another option for the patient with central spinal canal stenosis is percutaneous decompression of the spinal canal through this MILD procedure. The procedures involve debulking of the hypertrophied ligamentum flavum and small portions of the lamina using a percutaneous technique [43]. The procedure was introduced in 2015 by Vertos Medical and showed promising short-term results when compared to epidural steroid injections (ESI). They performed a randomized controlled trial of 302 patients. Primary efficacy was the proportion of Oswestry disability index (ODI) and at 1 year it was 58% in the MILD group versus 27.1% in the active control group [44]. In June 2018, they released the data for their 2-year follow-up to demonstrate the long-term durability of the procedure. Only patients in the MILD arm were followed past the first year. They reported ODI improvement of 22.7 points as well as improvements in numeric pain rating scale (NPRS) and Zurich Claudication Questionnaire (ZCQ). Patients had low device/procedure-related adverse events (1.3%) and there were no serious device/procedure-related adverse events [45••]. Results of the prospective RCTs are summarized in Table 2.

Interspinous Process Spacer (IPS)

An interspinous process spacer is a small implant that is inserted between the spinous processes of two contiguous lumbar levels where there is spinal stenosis. It acts by spinous process distraction, increasing the space between those two spinous processes and relieving the compression on the spinal cord and thus neurogenic claudication [48]. In a neurophysiological study by Schizas et al., they found that distraction of just 8 mm was enough to provide comparable electrophysiological improvement to decompression surgery [49].

There are multiple options for interspinous spacers available including the Wallis System (Abbott Spine, Austin, Texas), X-Stop (St. Francis Medical Technologies, Concord, California), DIAM (Sofamor Danek, Memphis, Tennesee), and Coflex (Paradigm Spine, New York, New York). Studies have shown that IPS can be analogous to surgical decompression in moderate spinal stenosis [50]. Recently, there has been more emphasis on percutaneously placed IPS [51•]. There have been multiple studies involving Superion (Vertiflex Inc., San Clemente, California). Patel et al. found that the Superion was non-inferior when compared to the X-Stop in controlling neurogenic claudication in patients with LSS [48]. More recently, Meyer et al. conducted a RCT with 163 patients randomized to receive either percutaneous IPS or standard decompression surgery. They found that IPS was non-inferior to surgery with similar rates of improvement in claudication. However, the IPS group had 18.2% reoperation rate as opposed to 9.3% in the surgery group. While results are promising, there are many limitations to the use of IPS. For example, it is contraindicated in patients with disease spanning more than two segments, spondylolisthesis and osteoporosis [52]. More prospective long-term RCTs are needed to provide a recommendation regarding the use of IPS.

Spinal Cord Stimulator (SCS)

Implantable pulse generators (IPG) and spinal cord stimulator leads were hypothesized to be effective against pain caused by neuropathy, ischemia, or mixed type pain. There have been studies that showed the use of SCS to be effective for patients with lumbar spinal stenosis.

In 2010, Costantini et al. reported their experience on SCS implants in patients with LSS [53]. The study included 69 patients (37 males) with an average age of 70 years (range 46–94). Patients underwent a trial first (length of time was not specified) and offered a permanent implant if they had > 50% reduction in pain. All 69 patients had a positive trial and underwent spinal cord stimulator placement. Patients were evaluated via a visual analog scale (VAS) and ODI. During

Table 2 List of prospective randomized controlled trials

Trial	Intervention	Control	# of patients	Outcome	Double blind
Elsheikh et al. 2016 [46]	Calcitonin + Local anesthetic + steroid	Local anesthetic + steroid	132	Significant reduction in VAS pain score, ODI score, walking distance, and analgesic consumption after 2 months of follow-up and up to a year.	Yes
Benyamin et al. 2016 [44]	MILD	ESI	302	MILD group showed 58% responder rate vs. 27.1% in the active control group ($P < 0.001$).	No
Staats et al. 2018 [45••]	MILD	ESI	274	Continued improvement in ODI scores of the MILD group.	No
Malmivaara et al. 2007 [47]	Laminectomy and transpedicular fusion	Conservative treatment	94	At 1 year, surgery arm had slight improvement in disability, leg pain, and back pain. At 2 years, the difference was minimal.	No

VAS, visual analogue scale; ODI, Oswestry disability index; MILD, minimally invasive lumbar decompression; ESI, epidural steroid injection

their 24-month follow-up (± 17.8), VAS scores went from 7.4 to 2.8. ODI scores went from 34.3 to 15.7 at follow-up. In addition, patients had a significant reduction in the use of pain medications (opioids from 29 to 13%).

In 2014, Kamihara et al. conducted a study to evaluate the efficacy of SCS in patients with LSS and neurogenic claudication [54]. They selected 91 patients (35 men and 56 women) with an average age of 73.2 years. After appropriate evaluation and diagnosis, patients underwent SCS trial. Trials lasted for 7 days and were then removed and scheduled for an implant with a month. Those who had > 50% reduction in pain were considered to be responders. They had 65% (59 patients) that were responders. Of those, 41 patients (11 males and 30 females) went on to undergo permanent implantation. Patients had long-term follow-up for an average of 34.5 months. About 95% (39 patients) had consistent pain relief greater than 1 year after implantation.

Data available from current studies show promising results for those with lumbar spinal stenosis and neurogenic claudication who have failed conservative therapy and epidural steroid injections. SCS offers these patients a minimally invasive treatment alternative to surgical decompression.

Surgery

Surgery is usually reserved for those who fail conservative measures, fail to improve with minimally invasive treatments, or who develop severe lumbar spinal stenosis. Surgical options to achieve adequate spinal decompression include laminectomy and interpedicular fusion. In a recent Cochrane meta-analysis by Zaina et al., it was difficult to determine if surgical intervention was superior to nonsurgical or conservative interventions [55•]. Zaina et al. evaluated 26 studies and five RCTs. The RCTs compared surgical versus nonsurgical treatments in 642 patients (average age 59), 322 were assigned to surgery and 321 were assigned to non-operative interventions. In comparing surgical decompression with multimodal non-operative treatment, the meta-analysis cited no significant differences between the two groups at 6 months or 1 year. At 24 months, the study cites low-quality evidence favoring the surgical decompression group.

When it comes to surgical technique, there is also some conflicting data regarding spinal decompression and fusion versus decompression alone. Forsth et al. showed that fusion increases intraoperative length, which increases bleeding, and the need for blood transfusions [56•]. This in turn increases the length of hospital stay and total cost. In their study, they selected 247 patients undergoing decompression and assigned them to either decompression only or decompression plus fusion. In addition to finding no difference in ODI after 2 years, they found that the 6.5-year reoperation rate was 22% in the fusion group and 21% in the decompression only group. Tye et al. examined the outcomes of decompression alone versus decompression plus fusion in workers' compensation cases. They reviewed the cases of 364 patients and found that patient that underwent decompression only had a higher return to work rate (36% vs. 25%) [57•]. Results of prospective RCTs are summarized in Table 2.

Conclusion

In reviewing current diagnostic criteria, we find that there is still a lack of a "gold standard" for diagnosing lumbar spinal stenosis. The Delphi consensus provides us with 7 questions that serve as a tool to help clinicians in the diagnostic process of patients with LSS. Further studies are necessary to reach an agreement on the diagnostic requirements for the disease.

In general, we found that there has been a limited amount of high-quality randomized control trials (RCTs) comparing the efficacy of the different treatment modalities for neurogenic claudication caused by lumbar spinal stenosis. In reviewing conservative treatment options, we found that while one study showed promise of efficacy of subcutaneous calcitonin, there were multiple other ones showing its lack of efficacy. In regard to prostaglandins, gabapentin, and methylcobalamin, the

current quality of evidence does not support making any recommendations on their efficacy in treatment. However, experience has shown gabapentin to be the most effective non-narcotic alternative in relieving neurogenic pain in patients with lumbar spinal stenosis. As a mainstay of treatment, we routinely recommend physical therapy to patients. However, current evidence does not support the efficacy of therapy with available trials being of "low" to "very low quality" of evidence.

In evaluating current available data on minimally invasive treatment, we found that evidence supporting epidural steroid injections is still conflicting. The data best supports the efficacy of use of lidocaine alone and lidocaine plus steroid injections. Nonetheless, the steroid component of the injections remains a standard component of epidural injections in most practices. Perhaps, data with longer follow-up time (>6 months) of patients can shed more light on the utility or efficacy of the steroid in these injections. The MILD procedure is a promising alternative to surgery for patients with central canal stenosis especially since the 2-year follow-up results were positive. SCS is another alternative to surgery for patients with LSS but evidence from RCTs and long follow-up is lacking.

Compliance with Ethical Standards

Conflict of Interest Shadi Messiah, Antony R. Tharian, Kenneth D. Candido, and Nebojsa Nick Knezevic declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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