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Focused Review

Role of Caudal Epidural Injections in the Management of Chronic Low Back Pain

Vijay Singh, MD* and Laxmaiah Manchikanti, MD**

Caudal epidural administration of corticosteroids is one of the commonly used interventions in managing chronic low back pain. Reports of the effectiveness of all types of epidural steroids have varied from 18% to 90%. Sicard, a radiologist, was the first to describe injection of dilute solutions of cocaine through the sacral hiatus into the epidural space in 1901, to treat patients suffering from severe, intractable sciatic pain or lumbago. This was followed by an explosion of reports and evolving interest in caudal epidural steroids with two additional reports in 1901 and numerous other reports over the years.

The philosophy of epidural steroid injections is based on the premise that the corticosteroid delivered into the epidural space attains higher local concentrations over an inflamed nerve root and will be more effective than a steroid administered either orally or by intramuscular injection.

The clinical effectiveness evaluations fill the literature with various types of reports including randomized clinical trials, prospective trials, retrospective studies, case reports, and meta-analyses. Evidence from all types of evaluations with regards to the clinical and cost-effectiveness of caudal epidural injections is encouraging.

This review discusses various aspects of the role of caudal epidural injections in the management of chronic low back pain, including pathophysiology of low back pain, indications, clinical effectiveness and complications.

Keywords: Caudal epidural injections, steroids, chronic low back pain, complications

Sciatica is called "one of the great scourges of humanity" (1-4). Low back pain or sciatica in early days as a clinical phenomenon dates back to Domenico Cotugno's *De Ischiade Nervosa Commentarius* in 1764 (1-4). An understanding of the cause of low back pain, or sciatica, remained elusive until the early 1900s (3). Case reports of ruptured intervertebral discs were reported as early as 1896 but were not considered to be a cause of sciatica. Mixter and Barr (5) were the first to create widespread interest in the disc as a source of pain, with publication of their 1934 hallmark description of herniated nucleus pulposus. However, after continued research and debate, low back pain after seven decades continues to be an enigma, even in the 21st century.

Epidural administration of corticosteroids is one of the commonly used interventions in managing chronic low back pain (6). The lumbar epidural space is accessible either by caudal, interlaminar, or transforaminal routes (6). Reports of the effectiveness of all types of epidural corticosteroids irrespective of route of administration have varied from 18% to 90% (6), and though numerous publications over the years have described administration of lumbar epidural steroid injections by various routes (6-22). Most of the analyses (7, 8, 11-20) have failed to separate the three approaches. Bogduk et al (9), and Manchikanti et al (6) evaluated the effectiveness of caudal epidural steroid injections separate from transforaminal and interlaminar epidural injections. These investigators (6, 9) have shown caudal epidural steroids overall to be superior to interlaminar epidural injections and equal to transforaminal epidural injections. Further, there has been only one study which compared the effectiveness of the three routes of epidural steroid injections in chronic low back pain, namely the caudal, interlaminar and transforaminal (23). Another

From Pain Diagnostic Associates, Niagara, Wisconsin and Pain Management Center of Paducah, Paducah, Kentucky. *Dr. Singh is Medical Director at Pain Diagnostic Associates. **Dr. Manchikanti is Medical Director at the Pain Management Center of Paducah. Address correspondence: Vijay Singh, MD, 1601 Roosevelt Road, Niagara, WI 54151 E-mail: vsingh@netnet.net

study (24) compared caudal and interlaminar epidurals, showing no significant difference between the two approaches.

HISTORICAL CONSIDERATIONS

Historical development of caudal epidural injections was contentious and hasty. Jean-Anthanase Sicard (25), a radiologist, was the first to describe injection of dilute solutions of cocaine through the sacral hiatus (the caudal route) into the epidural space in 1901, to treat patients suffering from severe, intractable sciatic pain or lumbago. One week later but independently, in 1901, Cathelin (26), urologist, described caudal administration of local anesthetic for surgical procedures and also injection of cocaine for relief of pain due to inoperable carcinoma of the rectum. In the same year, Pasquier and Leri (27), also independently, reported the use of caudal epidural injection for the relief of sciatic pain. The extension of this technique to the treatment of sciatica is attributed to Caussade and Queste (28) in 1909, Viner (29) in 1925, Evans (30) in 1930, Cyriax (31, 32) from 1937 to the 1970s, and Brown (33) in 1960. Lumbar epidural anesthesia was described by Pages in Spain in 1921 (34). Ever since this description of lumbar epidural anesthesia, the glory of caudal epidural blockade not only ended, but also suffered from comparison with interlaminar neural blockade, considered as more favorable in anesthesia.

The development of caudal epidural administration of local anesthetic technique also contributed to the development of contrast radiology (35). Sicard (25) with Forestier (36), first examined the epidural space in 1921. Sicard and Forestier (36-39), in a series of publications starting with examination of the epidural space with contrast (36), described examination of the subarachnoid space (37) and the technique of myelography (38).

Initial use of corticosteroids into the epidural space was through sacral nerve roots as reported by Robechhi and Capra (40) and Lievre et al (41), in 1952 and 1953. Cappio (42), in 1957, reviewed the literature and reported good results in 67% of 80 cases with caudal administration of steroids. The literature was initially dominated by reports in Europe (9). The first meaningful American study was published in 1961 by Goebert et al (43), addressing 113 patients, 86 of whom received caudal epidural injections, with 72% obtaining greater than 60% relief of their pain. Since then the literature has been replete with numerous retrospective studies, case reports, and meta analyses; some randomized clinical trials; one study comparing three routes of administration of lumbar epidural steroids, and an additional study comparing interlaminar and caudal routes in managing chronic low back pain (23, 44, 45-65). The chronology of the evolution of caudal epidural injections is described in Table 1.

PATHOPHYSIOLOGIC CONSIDERATIONS

Tissues in the lower back capable of transmitting pain in-

Table 1. *Chronology of evolution of caudal epidural injections*

1901 – Sicard (25) First reports of caudal local anesthetic
1901 – Cathelin (26) Caudal local anesthetic for surgery and relief of rectal pain
1901 – Pasquier and Leri (27) First epidural for sciatica
1909 – Caussade and Queste (28) Cures of sciatica with epidural
1921 – Sicard and Forestier (36) First epidurogram
1928 – Viner (29) Routine use of caudal local anesthetic for sciata
1930 – Evans (30) Large volume caudal injections
1951 – Bresgen (105) Considered pain provocation with caudal to indicate organic origin
1953 – Cappio – (42) Use of caudal epidural steroids
1960 – Brown (33) Pressure caudal anesthesia
1960s – Cyriax (31, 32) High volume caudal anesthesia
1961 – Goebert et al (43) First US report

clude the disc, nerve root dura, muscle, ligament, fascia, and facet joint (66). Pain from lumbar disc herniation can arise from nerve root compression and stimulation of nociceptors in the anulus or posterior longitudinal ligament. Mixter and Barr in 1934 described intervertebral disc herniation, which led many practitioners to assume that intervertebral disc herniation is the most common cause of back problems (5). However, modern evidence implicates intervertebral disc herniation in only a small percentage of back complaints (6, 67-72). Thus, a simple ideological explanation of compression or mass effect lacks practical application. Several studies evaluating the progress of disc herniation also have shown that, even though the resolution of symptoms tends to be associated diminution of the size of the disc herniations, it is not always the case, as compression may continue in spite of resolution of the symptomatology (72-76). It is also well described in many studies (77-80) that asymptomatic individuals present with disc herniations that are evident on computerized tomographic axial scan or on magnetic resonance imaging scan. A multitude of mechanisms have been proposed to explain radicular pain, which include partial axonal damage, neuroma formation, and focal demyelination (81); intraneural edema (82-85); and impaired microcirculation (84, 85). Further, the theory of chemical irritation and inflammation around the discs and nerve roots is also considered a major contributor in conjunction with or without mechanical factors.

RATIONALE

The philosophy of epidural steroid injections is based on the premise that the corticosteroid delivered into the epidural space attains higher local concentrations over an inflamed nerve root and will be more effective than a steroid administered either orally or by intramuscular injection (9, 44, 86, 87). Target site concentration of steroids depends on multiple injection variables, including the route of administration. Transforaminal epidural injections are considered as target specific (86-88). In contrast, interlaminar epidural injections, as well as caudal epidural injections, are considered nonspecific. Steroids may be prevented from migrating from the posterior epidural space to the anterior or ventral epidural space by the presence of epidural ligaments or scar tissue, either with caudal or interlaminar administration. Interlaminar lumbar epidural injections are alleged by some to be superior and target specific to caudal epidural injections. However, the extradural placement of the needle, which may go unrecognized without fluoroscopic guidance, is of importance (6, 9, 44, 89, 90). Other disadvantages of the interlaminar approach include erroneous placement of the needle, which may miss the targeted interspace without fluoroscopic guidance (90, 91); preferential cranial flow of the solution in the epidural space (91, 92); deviation of the needle to the nondependent side; difficulty entering the epidural space and delivery of injectate below L5, for S1 nerve root involvement; potential risk of dural puncture and postlumbar puncture headache; and, finally, the rare, but serious, risk of spinal cord trauma (93, 94).

Similar to interlaminar epidural injections, transforaminal epidural injections also have some disadvantages; however, they are much less frequent and significant in terms of maintaining the target delivery of corticosteroid (86-88). These disadvantages of transforaminal epidurals include intravascular penetration of the needle, neural penetration, and spinal cord trauma.

Caudal epidurals have been described as very effective, with easy entry without dural puncture. However, the criticism has been made that the caudal epidural injection necessitates injection of a substantial volume of fluid, which essentially dilutes the corticosteroid concentration to the target site (6, 9, 95). Further disadvantages are intravascular and extravascular placement of the needle (95-107). Additionally, it has been described that corticosteroid administered caudally does not reach the presumed target site, (the ventral epidural space in front of the dural sac and behind the disc). Studies have shown that in normal volunteers the transforaminal approach showed good target specific ventral flow (108). However, following interlaminar epidural injection of contrast, the flow was predominantly dorsal, far removed from the usual site of inflammation (108). No such studies have been conducted evaluating the distribution of contrast following caudal epidural injection. Various factors leading to the failure of epidural corticosteroid injections are described by Saal and Saal (109).

The rationale for epidural steroids focused on strong anti-inflammatory effects of corticosteroids (9). Propositions were made that sciatica might be directly associated with inflammation (9, 47, 110-122). The first direct evidence of inflammation in patients with radiculopathy was documented in 1981 (123). Ryan and Taylor (123), by examining samples of CSF during administration of intrathecal and epidural injections, observed that inflammation was a critical component of radicular pain. They also reported that intraspinal steroids were likely to act best when this inflammation was still acute, before the pathology had progressed to nerve root fibrosis or axonal death. Conse-

quently, they classified patients with lumbar radiculopathy into two categories, namely, compressive and irritative radiculopathy.

The present clinical rationale for steroid usage in caudal epidurals is primarily based on the benefits, which include pain relief outlasting by hours, days, and sometimes weeks, the pharmacological action of steroids and local anesthetics. However, appropriate explanations for such benefits continue to lack scientific validity. Additional explanations include alteration or interruption of nociceptive input, reflex mechanism of the afferent limb, self-sustaining activity of the neuronal pools in the neuraxis, and the pattern of central neural activities by neural blockade, including caudal epidural steroids (124). The basis for these explanations is twofold. First, it is postulated that corticosteroids reduce inflammation either by inhibiting the synthesis or release of a number of proinflammatory substances or by causing a reversible local anesthetic effect (125-139). Second, administration of epidural solutions clears or dilutes the chemical irritants. Corticosteroids are postulated to exert their effect by multiple modes, including membrane stabilization, inhibition of neural peptide synthesis or action, blockade of phoslolipase A_2 activity, prolonged suppression of ongoing neuronal discharge, and suppression of sensitization of dorsal horn neurons (140, 141).

Inflammatory reactions between the nucleus pulposus and nerve roots have been suggested as playing an important role in disc herniation with sciatica. However, the pathogenic mechanisms linking herniated nucleus pulposus, nerve root injury, and sciatica are not clearly demonstrated (109-123, 142-157). It has been postulated that sensory neurons in the associated dorsal root ganglia are affected by the chemical injury, and the behavioral pattern changes observed in the irritating nerve root model are caused in part by a high level of phospholipase A_2 activity initiated by inflammation (134). The mechanism of action of epidural steroid injection in this model was inhibition of phospholipase A_2 activity (134). Thus, these investigations (130, 133-135, 158) provide clinical support for use of epidural steroid injections in managing chemical irritation and inflammation around the discs and nerve roots. Experimental evidence shows epidural application of the nucleus pulposus to induce pronounced morphologic and functional changes in the nerve roots (144). Intravenous (IV) methylprednisolone was shown to reduce the nerve root injury secondary to nucleus pulposus in the epidural space (130). Epidural injection of betamethasone in a model of lumbar radiculopathy showed a significant effect on thermal hyperalgesia (133). In an experimental study in the rabbit, it was shown that lipopolysaccharide accelerated the process of herniated intervertebral disk resorption, whereas high dose steroid suppressed the process (135). Lee et al (134) evaluated the role of steroids and their effects on phospholipase A_2 in an animal model of radiculopathy, showing a steady reduction in phospholipase A_2. Byrod et al (139) also showed that methylprednisolone reduces the early vascular permeability increase in spinal nerve roots induced by epidural nucleus pulposus application in the pig experimental model.

However, the basis for the relief obtained from epidural Sarapin, as well as other agents at present is not known.

CLINICAL EFFECTIVENESS

The literature is replete with numerous opinions, which are not only contradictory, but also confusing, on the clinical effectiveness of epidural steroid injections in general and caudal epidural steroids in particular. Various reports of clinical effectiveness include randomized clinical trials with or without blinding; prospective trials; retrospective studies, either randomized or nonrandomized; case reports; and, finally, meta analyses. Unfortunately, clinical trials of the efficacy of commonly used interventions in low back pain reviewed by Koes et al (159), Van Tulder et al (160, 161) and others (6, 7, 10-19, 162, 163) led to the conclusion that the methodological quality in these studies was disappointingly low. Further, most of the studies of epidural steroid injections have been performed by multiple specialty groups (rarely including interventional pain specialists) and without fluoroscopy. Epidural administration of steroids is ideally performed under fluoroscopic guidance (164).

Randomized, double-blinded studies are considered to represent the best available evidence. Thus, clinical efficacy of any intervention presumably is ideally measured by randomized, double-blind trials. Many stumbling blocks including the issues of ethics, feasibility, cost and reliability, pose frequently insurmountable challenges to randomized, double-blind trials in interventional pain medicine (6). In addition, the value of the so-called "gold standard" of a randomized, double-blind trial has been questioned. Benson and Hartz (165) outlined several advantages of observational studies over randomized, controlled trials including lower costs, greater timeliness, and a broader range of patients. They compared the results of observational studies with those of randomized, controlled trials. They concluded that in most cases, the estimates of the

Table 2. *Cumulative significant relief (>50%) in weeks by number of procedures*

No. of procedures	Blind interlaminar (mean + SEM)	Fluoroscopic caudal (mean + SEM)	Fluoroscopic transforaminal (mean + SEM)	F-ratio (P value)
1	1.1 + 0.04(69)	3.0 + 1.27(66)	1.6 + 0.17(68)	1.6482(0.1950)
2	3.1 + 0.13(69)	5.2 + 0.74(66)	8.4*# + 1.74(68)	5.9386(0.0031)
3	6.7 + 0.37(60)	10.3 + 0.96(56)	20.6*# + 4.20(56)	8.6606(0.0003)
4	11.3 + 0.61(48)	18.4 + 1.71(47)	24.2* + 3.57(42)	8.6922(0.0003)
5	15.5 + 1.02(33)	24.7 + 2.35(38)	32.7*# + 4.05(33)	9.4497(0.0002)

* Indicates significant difference: Group I vs. Group II or Group III # Indicates significant difference: Group II vs. Group III
SEM = Standard error of mean Adapted and modified from Manchikanti et al (23).

treatment effects from observational studies and randomized, controlled trials were similar. Concato et al (166) in evaluating various types of clinical evaluations concluded that the average results of observational studies were remarkably similar to those of randomized, controlled trials and that the results of well-designed observational studies do not systematically overestimate the magnitude of the effects of treatment as compared with those in randomized, controlled trials on the same topic. Bogduk et al (9), in the report prepared by the working party set up in March 1991 by the Healthcare Committee of the National Health and Medical Research Council of Australia to examine the value of epidural use of steroids in the management of back pain, concluded that all reports on the use of caudal epidural steroids have been favorable with respect to benefits.

The first uncontrolled but significant study by Goebert et al (43) evaluated a series of 121 injections administered to 113 patients with radicular pain, of which 94 were caudal epidural injections. Epidural injections of 30 mL of 1% procaine combined with 125 mg of hydrocortisone acetate (the intra-articular suspension) were employed usually for 3 consecutive or alternate days. They reported overall good results in 72% of the patients, with poor results in 17%. They reported good results in only 50% of patients with suspected disc protrusion, while 76% of the patients with radiculopathy following laminectomy and 86% of the patients with radiculopathy from other causes showed good results. In another study from the same center, Gardner et al (46) reported that 137 out of 239 (53%) patients with sciatica reported 60% to 100% pain relief for a minimum period of 3 months. Lindholm and Salenius (56) reported good results at 2 to 6 months in 10 out of 13 patients with back pain attributed to disc degeneration, in 12 out of 14 patients with nerve root compression, and in 3 of 5 patients with presumed ligament strain. Mount (49) studied 545 patients suffering from nonspecific lumbar intervertebral disc syndrome, reporting complete relief in 292 patients and greater than 85% relief in 104 patients. Sharma (52) reported results in 201 patients suffering with lumbago, sciatica, backache with sciatica, and other conditions with favorable pain relief in 56% of the patients.

Ciocon et al (63) studied the efficacy of caudal epidural blocks for elderly patients with lumbar canal stenosis, showing significant pain reduction for up to 10 months, with satisfactory relief in 90% of patients.

Manchikanti et al (23), in evaluating the effectiveness of caudal epidural steroid injections under fluoroscopic visualization, showed significant improvement that was better than that of blind lumbar interlaminar epidural injections. In this retrospective but consecutive evaluation, patients were divided into three groups with 75 patients in each group. Group I received blind lumbar epidural steroid injections, Group II received caudal epidural steroid injections under fluoroscopy, and Group III received transforaminal epidural corticosteroid injections under fluoroscopic visualization. Cumulative significant relief, which was defined as greater than 50% relief, was reported following three procedures for a mean of 10.3 + 0.96 weeks in patients receiving caudal epidurals, in contrast to 6.7 + 0.37 weeks in patients receiving blind lumbar epidural steroid injections (Table 2). However, the response to caudal epidural steroids was inferior to transforaminal epidural corticosteroid injections.

Most meta analyses by various authors have combined evaluations of all types of epidural injections. In developing guidelines for interventional techniques, Manchikanti et al (6) evaluated the effectiveness of epidural steroid injections separately, dividing them into caudal, interlaminar

and transforaminal. They showed that, of the six controlled trials, five showed positive results. Bogduk et al (9) concluded that caudal epidural steroids were clinically effective with a favorable profile. Koes et al (10, 12) reviewed the role of epidural steroid injections, including 12 trials of lumbar and caudal epidural steroid injections in 1995 and 15 trials in 1999. They reported positive results in 6 of the 12 trials in 1995 and 8 of the 15 trials in 1999. However, the separation of lumbar and caudal epidural steroid injections showed that, of the 5 studies for caudal epidural steroid injections in 1995, 4 were positive; whereas, of 15 trials in 1999, 5 included caudal epidural steroids, once again the same studies as the previous study, with 4 being positive. Watts and Silagy (15) in 1995 performed a meta analysis of the available data and defined efficacy in terms of pain relief (at least 75% improvement) in the short-term (60 days) and in the long-term (1-year). They concluded that epidural steroid injections increased the odds ratio of pain relief to 2.61 in the short-term and 1.87 in the long-term. McQuay and Moore (16) in 1988 reviewed the literature and concluded that epidural corticosteroid injections are effective for back pain and sciatica. However, the first systematic review of the effectiveness of epidural steroid injections by Kepes and Duncalf in 1985 (7) concluded that the rationale for epidural steroids was not proven. Benzon (8), a year later utilizing the same studies, concluded that mechanical causes of low back pain, especially those accompanied by signs of nerve root irritation, may respond to epidural steroid injections. Unfortunately, Kepes and Duncalf (7) also included studies on systemic steroids. Benzon (13), and Benzon and Molley (14) considered the role of epidural steroid injections controversial but recommended the continued use of epidural steroid injections as part of the overall management of patients with acute radicular pain, herniated disc, or new radiculopathy superimposed on chronic back pain. Nelements et al (17) evaluated the effectiveness of injection therapy, lumping together all types of epidural steroid injections, trigger point injections, facet joint blocks, and intradiscal steroids. In addition, they also failed to include all the relevant literature, and the conclusions were flawed. Vroomen et al (18) evaluated conservative treatment of sciatica, including epidural steroids, including a total of four studies which involved only one caudal.

Among the prospective but nonrandomized trials response has been encouraging. Yates (53) evaluated 20 consecutive patients, allocating them into four groups. He concluded that addition of steroid to any base mixture resulted in greater improvement. Waldman (57) evaluated the effectiveness of caudal epidural steroids in 53 patients with radicular pain distribution anatomically correlating with documented disc herniation and nerve root impingement, with administration of up to four caudal steroid injections. Results showed that combined visual analog scale and verbal analog scores for all patients were reduced 63% at 6 weeks, 67% at 3 months, and 71% at 6 months. White et al (44), in a prospective evaluation of 304 consecutive patients with low back pain, showed a short-term success of approximately 87%, with only 24% of the patients showing significant relief at 6 months without psychologic overlay and in 34% of the patients presenting with acute pain. Swerdlow and Sayle-Creer (58) studied 325 patients suffering from lumbosciatic syndrome, showing in a total of 67% of the patients in the methylprednisolone group significant improvement in the chronic group, whereas it was 72% in the acute group, and 61% in the patients with recurrent pain.

Manchikanti et al (65) evaluated effectiveness of caudal epidural injections in discogram-positive and negative chronic low back pain patients, including 45 patients with negative provocative discography, and 17 patients with positive provocative discography. Sixty-nine percent of the patients in the negative discography group and 65% of the patients in the positive discography group were in the successful category. Patients in the successful category responded with 1 to 3 injections, with cumulative relief of greater than 50% in 100% of the patients at 1 month; at 3 months, negative provocative discography declined to 86%; and at 6 months, both positive and negative provocative discography groups declined to 60% and 64% as shown in Fig. 1. As shown in Table 3, comparison of significant relief greater than 50% with each injection was significantly better in the negative provocative discography group with injections 5, 6, 7 and 8 compared to the positive provocative discography group. Comparison of overall health

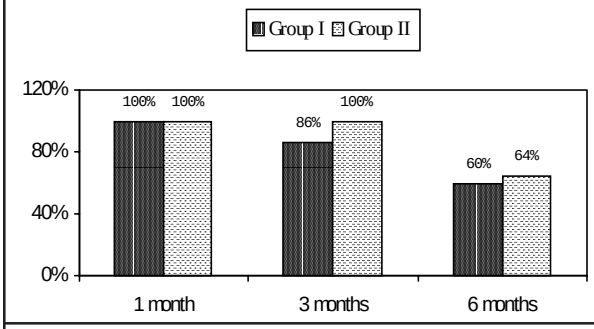

Fig. 1. Illustration of cumulative relief (>50%) with one to three injections (successful patients)
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Table 3. *Comparison of significant relief (>50%) with each injection by group in weeks, in successful category*

Injection Number	Group I Negative Discography		Group II Positive Discography	
	Mean + SEM	Range	Mean + SEM	Range
One	8.5 + 0.43 (31)	4 - 13	13.3 + 6.03 (11)	3 - 73
Two	8.7 + 0.51 (31)	3 - 13	8.7 + 1.02 (10)	4 - 13
Three	9.8 + 0.51 (25)	4 - 13	9.5 + 1.20 (8)	4 - 13
Four	12.4 + 1.80 (24)	4 - 13	9.4 + 1.51 (8)	0 - 13
Five	11.3* + 0.41 (19)	9 - 13	8.7 + 1.67 (6)	1 - 13
Six	10.7* + 0.48 (12)	9 - 13	5.0 + 2.92 (4)	0 - 11
Seven	12.1* + 0.49 (11)	9 - 13	6.0 + 3.00 (3)	0 - 9
Eight	11.8* + 0.65 (6)	9 - 13	7.5 + 1.5 (2)	6 - 9
Nine	11.0 + 2.00 (2)	9 - 13	5.5 + 3.50 (2)	2 - 9
Ten	-	-	9 (1)	9
Average	10.2 + 0.33	3 - 13	9.3 + 1.28	0 - 73

SEM = Standard error of mean * Indicates significant different between groups
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status, psychological status, and narcotic intake showed significant improvement in the successful category group compared to failed category group in comparison to pre-treatment and post-treatment. In addition, there was also significant improvement shown in terms of employment status with a significant proportion of patients (27%) being employed during the treatment and at the end of the treatment with no significant change noted in the employment category in failed categories in both groups (Fig. 2).

Thus far, the extensive literature available on caudal epidural steroid injections includes eight randomized, controlled trials with or without blinding (48, 50, 51, 55, 60-62, 64). Breivik et al (51), in a prospective, randomized, crossover study, evaluated 35 patients with chronic low back pain, allocated to treatment with up to three caudal epidural injections of bupivacaine and methylprednisolone or bupivacaine and normal saline at weekly intervals. During initial therapy 56% of patients receiving methylprednisolone experienced significant relief, compared to 26% with bupivacaine with saline. While 50% of the patients treated with steroids returned to work, 20% of the patients treated with bupivacaine returned to work. Bush and Hillier (60) in a double-blind, randomized study of 23 patients with lumbar radicular pain, demonstrated significantly greater pain relief and mobility with a significantly improved quality of life following triamcinolone injection. In contrast to the above studies, Beliveau (50) found no difference in pain relief between 24 patients treated with caudal injections of 40 mL of 1% procaine and 80 mg (2 mL) of methylprednisolone, and an equal number of patients treated with 42 mL of procaine alone. One to three months later they saw complete relief in 42% of the patients in the steroid group, and in 29% in the normal saline group. This study demonstrated the efficacy of caudal epidural injections in sciatica with or without steroids. Matthews et al (55) compared the responses of patients

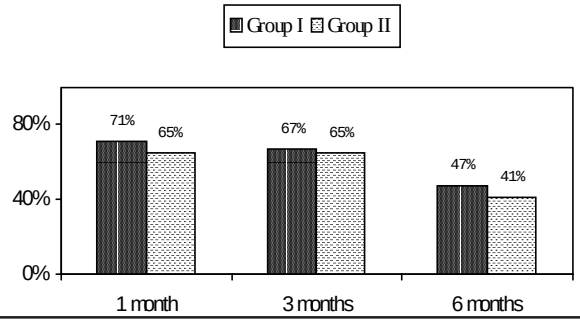

Fig. 2. Illustration of cumulative relief (>50%) with one to three injections (all patients)
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treated with caudal epidural injections of bupivacaine and methylprednisolone or a control injection of 2 mL of lignocaine over the sacral hiatus. While, at assessment after 1 month, there was no significant difference between the two groups, at 3 months, the treated group was reported to be significantly more pain free. Czarski (48) evaluated the use of caudal epidural injections, comparing Novocaine®, hydrocortisone and procaine hydrochloride alone in the treatment of patients with prolapsed lumbar intervertebral disc, with 60 patients in the procaine hydrochloride group and 123 patients in the procaine hydrochloride and hydrocortisone group. He demonstrated statistically significant and clinically significant differences in outcomes comparing the use of caudal epidural injections.

Manchikanti et al (64) studied 65 patients, with 15 patients in a control group (Group I), 22 patients in Group II receiving caudal epidural with local anesthetic and Sarapin, and Group III patients treated with local anesthetic and betamethasone. They showed significant improvement in the treatment group in terms of pain relief, functional status, psychological status, and employment status; narcotic intake also improved with one to three injections. Improvement was seen in 97% of the patients at 1 month, in 57% at 3 months, and in 17% at 6 months. Cumulative relief greater than 50% with 1 to 12 injections showed greater than 50% relief in 86% of the patients at 6 months and in 67% of the patients at 1 year. The study also showed that apart from the clinical effectiveness, the treatments were cost effective, with cost for 1 year improvement of quality of life on average for both groups at $2,550. Significant decrease was seen in heavy narcotic intake during post-treatment in treatment groups. Increase in employment was seen in both treatment groups. Fig. 3 illustrates the cumulative relief (greater than 50%) with 1 to 3 injections.

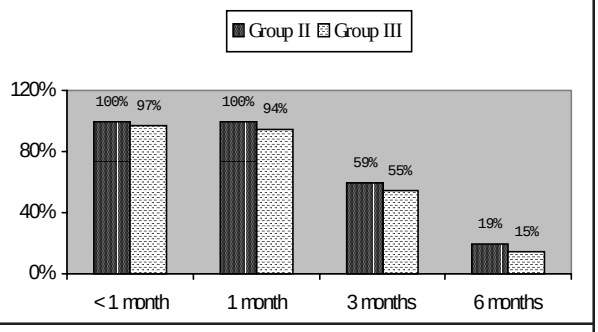

Fig. 3. Illustration of cumulative relief (>50%) with one to three injections

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There also have been two publications reporting the use of forceful caudal epidural injections in managing lumbosciatic pain with postoperative lumbar epidural fibrosis or failed lumbar laminectomy syndrome (106, 107). Both studies (a randomized trial (106), and a controlled, non-randomized trial) concluded that forceful epidural corticosteroid injections were better.

INDICATIONS

Caudal epidural steroid injections are indicated in patients with chronic low back pain who have failed to respond to conservative modalities of treatments. The procedure should always be performed under fluoroscopy. Patients should present with a strong radicular component or discogenic pain or at least they must not have facet joint pain or sacroiliac joint pain. Patients with combined pain generators with discogenic pain as well as facet joint pain may also receive caudal epidural steroid injections. While caudal epidural steroid injections may be performed for any type of low back pain with or without lower extremity pain nonresponsive to conservative modalities of treatments, they are properly indicated in patients negative for facet joint pain or patients who have a combination of discogenic component with facet joint pain. Caudal epidural steroids are the preferred modality of treatment for sacral involvement, in postsurgical patients, and in patients with bilateral involvement or multilevel involvement for which transforaminal epidurals will require multiple procedures at multiple levels.

In the past, a multitude of investigators has attempted to identify predictors of outcome of epidural injections, as well as facet joint injections. However, these attempts have been proven to be futile; hence, no such recommendations are made in this review. Various contraindications include the patient's inability to be in the prone position, contraindications for fluoroscopy, local or systemic infection, abnormalities of the sacrum, and allergy to any of the drugs used.

COMPLICATIONS

Caudal epidural injections are associated with occasional, but common and rarely worrisome, complications. These are related to dural puncture, spinal cord compression, infection, and toxicity of steroids (6, 140, 141, 167, 168).

Early reports of caudal epidural injections showed that large volumes of injectate were utilized. Evans (30) used up to 140 mL, with exceedingly rare occurrences of complica-

tions. Cyriax (31, 32) used high-volume injections in over 20,000 patients, with 50,000 injections utilizing 50 mL of procaine, and reported no major disasters and only five misfortunes, with one case of hypersensitivity, two cases of temporary paraplegia of the lower half of the body, and two cases of chemical meningitis; all patients recovered without lasting harm. Bogduk et al (39) reported that injected volumes tend to be variable from 10 to 64 mL for caudal injection of steroids and also stated that a volume of 10 mL should be used to reach the L5 segment and 15 mL should be used to reach the L4 segment. Complications have been reported with injections of high volumes into the epidural space, with increasing intraarticular pressure with retinal hemorrhage. Manchikanti et al (95) in a prospective study attempted to correlate optimal dose of injectate with filling defects observed on an epidurogram. They concluded that increasing the volume of injectate greater than 10 mL does not seem to improve the filling pattern.

Spinal cord compression following rapid injections into the epidural space, which may cause large increases in intraspinal pressure with a risk of cerebral hemorrhage, visual disturbances, headache, and compromise of spinal cord blood flow, has been mentioned. However, the only complication reported following epidural injection has been vision loss. Kushner and Olson (169) evaluated patients who complained of visual-field defects or blurred vision after receiving epidural steroid injections and concluded that retinal hemorrhage is uncommon but significant, and a previously unemphasized complication of epidural steroid injections in general. Retinal hemorrhages mainly have been attributed to rapid epidural injections of high volumes, causing a sudden increase in intracranial pressure, resulting in the increase of retinal venous pressure (169-175).

Epidural infection following this procedure is an extremely rare, but distinct, possibility due to the procedure itself, location of needle placement, and potential immunosuppression secondary to steroid injection. Sampath and Rigamonti (176), in a review of epidemiology, diagnosis, and treatment of spinal epidural abscess, noted that spinal nerve block was responsible for 7% of the patients, whereas a multitude of predisposing factors included IV drug use, diabetes neuritis, multiple medical illnesses, trauma, prior spinal surgery, morbid obesity, HIV disease, and end-stage renal disease, in descending order of frequency. Wang et al (177), in a 1-year study of the incidence of spinal epidural abscess after epidural analgesia, reported nine cases of epidural abscess formation from a total of 17,372 epidural catheters. Rathmell et al (178) noted that epidural abscess formation is an uncommon but devastating complication that has been associated not only with continuous epidural analgesia (179) but also with single epidural injections (180). They also postulated that epidural abscess most often arises in association with systemic infection, but it also rarely occurs following epidural analgesia (178).

Direct trauma to the spinal cord following lumbar epidural injections has been rarely reported, with disastrous complications (93, 94). However, none of the case reports involved caudal epidural injections. The incidents of intravascular placement of the needle during caudal epidural injections documented by contrast-enhanced fluoroscopic imaging and negative blood aspiration has varied from 5% to 11% (44, 95-98).

Spinal cord or epidural hematoma is a potential complication; however, no cases have been reported with caudal epidural injections (178-183), so the actual incidence, if any, is not known. The incidence with epidural injections cited in the literature is estimated to be less than 1 in 150,000 epidurals. Epidural hematomas have been reported following epidural analgesia in a patient with peripheral vascular disease receiving unfractionated heparin for thromboprophylaxis and paraplegia after epidural anesthesia

Accidental dural puncture and subarachnoid injection have been described with epidural injections, even though there are no specific descriptions relating to caudal epidural injections. Transient neurologic symptoms after epidural analgesia have been reported, which included cauda equina syndrome (183-194). Horlocker and Wedel (190) reported a 0.2% to 2.9% cardiac arrest rate, 0.2% to 1.2% death rate, 0.4% to 3.6% neurological injury rate, 0.5 to 3.8% radiculopathy rate, 0% to 1.2% incidence of cauda equina syndrome and 0% to 1.8% incidence of paraplegia after reviewing 30,413 epidurals. They also reported anterior spinal artery syndrome's leading to spinal cord ischemia, resulting in flaccid paralysis of the lower extremities (190-195).

Other side effects are related to the administration of steroids and are generally attributed to the chemistry or pharmacology of the steroids. The safety of steroids and preservatives at epidural therapeutic doses has been demonstrated in both clinical and experimental studies (140, 141, 196-203). The major theoretical complications of corticosteroid administration include arachnoiditis, suppression of the pituitary-adrenal axis, hypocorticism, Cushing's syn-

drome, osteoporosis, avascular necrosis of bone, steroid myopathy, weight gain, fluid retention, and hyperglycemia (140, 141, 204-214). Other potential complications include hypertension, hypokalemia, epidural lipomatosis, subcapsular cataract formation, insomnia, mood swings, psychosis, facial flushing, headache, gastrointestinal disturbances, and menstrual disturbances (140, 141). Manchikanti et al (204) evaluated the effect of neuraxial steroids on weight and bone mass density (BMD) prospectively. They concluded that low-dose neuraxial steroids are safe in patients with chronic pain who have failed to respond to conservative modalities of treatments with a favorable risk-benefit ratio, without any deleterious effects either on body weight or BMD. Cousins (215) reported that an additional potential complication of administration of depo-corticosteroids related to inadvertent intravascular administration, producing occlusion of small end arteries which resulted in visual defects in one case (216) and hearing loss in another case involving suboccipital nerve block. Abram (217) also acknowledged the potential for harm from occlusion of small-end arteries by steroid suspensions. Abram (217) felt that prednisolone acetate tends to form aggregates of the steroid material when mixed with local anesthetic and may pose more of a risk for this problem than other depo-steroids. However, preparations of either methylprednisolone or triamcinolone could produce devastating consequences if injected into a spinal artery. In this aspect, betamethasone appears to be the safest, as it is most soluble with local anesthetic.

Botwin et al (107) studied complications of fluoroscopically guided caudal epidural injections. They showed that in 139 patients, with 257 injections over a 12-month period, complications per injection included, in descending order of frequency, insomnia (4.7%), transient nonpositional headaches (3.5%), increased back pain (3.1%), facial flushing (2.3%), vasovagal reactions (0.8%), nausea (0.8%), and increased leg pain (0.4%).

CONCLUSION

Caudal epidural steroid injections are simple, safe, and effective techniques for managing chronic low back pain. Much of the confusion surrounding caudal epidural steroid injections is based on a lack of understanding as well as a lack of appropriate evaluation of their effectiveness, along with the usual overemphasis on biopsychosocial problems and inappropriate selection of patients. Considering the cumulative evidence available in the literature, caudal epidural steroid injections are as effective as numerous other interventions applied in managing chronic low back pain, if not superior.

Even though caudal epidural steroid injections are effective, safe and simple techniques in managing chronic low back pain, caution must be exercised, as there are significant risks associated with this technique. An interventional pain physician needs to individualize the choice of treatment to each patient and personal experience. Caudal epidural steroid injections should only be performed when medically necessary, based on the progress of the patients, to provide cost-effective care without creative billing. They are best performed under fluoroscopic visualization.

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