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Predictive factors for treatment success of epidural steroid injections in patients with lumbar spinal surgery

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Abstract. – OBJECTIVE: The efficacy of epidural steroid injections (ESIs) in the treatment of radicular pain in patients undergoing lumbar spinal surgery is still unclear. The aim of this study was to investigate the factors affecting the success of ESIs in the treatment of ongoing radicular pain in patients undergoing lumbar spinal surgery.

PATIENTS AND METHODS: This study was designed as a single-center, retrospective study, and was conducted at a Pain Management Center of a tertiary care center. A total of 260 patients with failed back surgery syndrome who received fluoroscopy-guided lumbar ESI were included. Treatment success was defined as ≥50% reduction in the numeric rating scale score at the one-month follow-up. The patients were divided into the treatment success and the treatment failure groups.

RESULTS: The presence of spinal instrumentation was significantly lower in the treatment success group (p=0.045). Symptom duration and the numeric rating scale score at 1 hour were significantly lower in the treatment success group (p<0.05). The use of triamcinolone acetonide in the treatment success group was found to be significantly higher than in the treatment failure group (p=0.027).

CONCLUSIONS: The short duration of symptoms and the absence of instrumentation seem to be prognostic factors that positively affect the success of ESI treatment in operated patients. A ≥50% pain reduction in the first hour after the procedure is a valuable indicator that treatment success can be achieved in the short term. Finally, the steroid type can also affect the treatment results.

Key Words:
Epidural Injections, Lumbar spinal surgery, Failed back surgery syndrome, Lumbar radicular pain.

Introduction

Lumbar epidural steroid injections (ESIs) are the preferred interventional pain procedures in patients with lumbar radicular pain unresponsive to conservative treatment. They can be applied by caudal, interlaminar, or transforaminal approach[1]. They are effective treatment options in the short and medium term in selected cases evaluated clinically and radiologically[1,2]. However, there are few studies[3,4] in the literature on ESI's efficacy in treating radicular pain in patients undergoing lumbar spinal surgery. Lee et al[3] reported that ESIs had positive effects on pain and functionality at a six-month follow-up in patients undergoing lumbar spinal surgery. Manchikanti et al[4] showed that caudal ESI could be effective for two years in patients undergoing lumbar spinal surgery.

Predictive factors that may affect the outcome of lumbar ESI treatment have been previously investigated[5-10]. Some of these studies[6,9] have addressed clinical factors, while some others have focused on radiological factors[5,8], and some others[7,10] have investigated the effects of both clinical and radiological factors on outcomes. However, there is no comprehensive study in the literature investigating predictive factors for the success of lumbar ESI in patients with a history of lumbar spinal surgery. The only research on this topic was conducted by Um et al[11]; they investigated the effectiveness of lumbar transforaminal epidural injections in recurrent disc herniations after discectomy. In this study, ESI was applied to 37 patients who underwent lumbar surgery, and only the transforaminal approach was used. In addition to the small sample size, many factors investigated in the current study were not taken into account by Um et al[11]. In addition, among the many causes in the etiology of failed back surgery syndrome (FBSS), those who received injection therapy for only one specific cause were included in the study[11,12]. Therefore, it makes it difficult to make a robust conclusion about predictive factors of ESI in operated patients.

The growing geriatric population increases the number of patients with persistent pain despite

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undergoing lumbar spine surgery. Currently, epidural injections are being performed more and more widely worldwide[13]. These treatments in operated patients can reduce the revision surgeries[2]. In addition, ESIs are relatively cost-effective and can decrease the burden of low back pain. Furthermore, they contribute to the restoration of functions[14]. In this context, it is critical to identify factors to predict the effectiveness of epidural injections in operated patients.

In the present study, we aimed to investigate the factors affecting the success of ESI in the treatment of ongoing radicular pain in patients undergoing lumbar spinal surgery.

Patients And Methods

Study Design and Study Population

This single-center, retrospective study was conducted at the Pain Management Center, Department of Physical Medicine and Rehabilitation of a tertiary care center. Prior to the study, written informed consent was obtained from the patients. The study was approved by the institutional Ethics Committee (09.2023.357) and conducted in accordance with the principles of the Declaration of Helsinki.

Patients who received fluoroscopy-guided lumbar ESI between January 2021 and January 2023 were screened. Data from all patients were collected from hospital medical documents [demographic data, Numeric Rating Scale (NRS) score, type of procedure, and medical treatment]. A total of 1,414 patients were screened for the study, and considering inclusion and exclusion criteria, a total of 260 patients were included in the study. Inclusion criteria were as follows: age >18 years, had a history of lumbar disc herniation surgery, and having an ESI (lumbar interlaminar, lumbar transforaminal, or caudal approaches) for non-relieving lumbar radicular pain after surgery and conservative methods. Patients with a history of major psychiatric disorders, missing first-month follow-ups, had an epidural injection in the last three months, and patients without demographic or clinical data were excluded from the study (Figure 1). Triamcinolone or betamethasone was used as a steroid in all procedures, and all procedures were performed by a pain medicine specialist with at least 10 years of experience. Patients undergoing surgery were classified as the presence or absence of instrumentation. In addition, the patients were classified according to the type of procedure. Treatment success was defined as ≥50% reduction in the NRS at the one-month follow-up. The patients were divided into two groups as the treatment success (TS) group and the treatment failure (TF) group.

Statistical Analysis

Statistical analysis was performed using the SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed in mean ± standard deviation (SD), median (min-max), or interquartile range (IQR), while categorical variables were expressed in number and frequency. The Chi-square test was used to compare categorical variables. The Shapiro-Wilk test was used to analyze the distribution of quantitative data. The Mann-Whitney U test was performed for the comparison of non-normally distributed data, while the independent t-test was used to compare normally distributed data. Multivariate binary logistic regression analysis was performed to calculate the odds ratio (OR) and 95% confidence interval (CI). A p-value <0.05 was considered statistically significant.

Results

A total of 260 patients were included in the study. Of the patients, 155 (59.6%) were female.

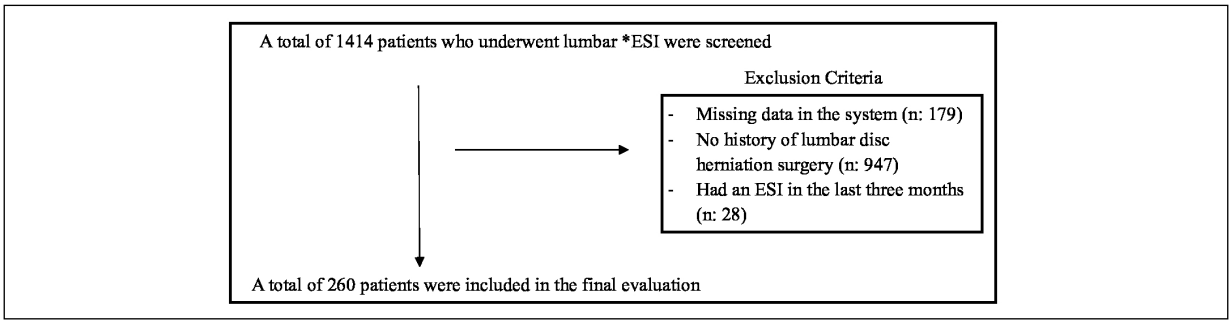

Figure 1. Study flowchart.

The mean age of all patients was 54.53 (range, 22 to 92) years. The median symptom duration of the patients was 19.55 (range, 1 to 144) months. Before the procedure, the mean NRS score of the patients was 8.37±1.21, 1.28±0.21, and 3.71±0.30 at 1 hour and one month after the procedure, respectively. Of the patients, 23.8% were using opioids, 54.2% were using one of the gabapentinoids, and 15.4% were using duloxetine. The most common type of procedure was the transforaminal epidural injection, in 179 (68.8%) of patients. Betamethasone sodium phosphate/betamethasone acetate (n=171, 65.8%) and triamcinolone acetonide (n=89, 34.2%) were used as steroids. Finally, the number of patients who achieved treatment success was found to be 163 (62.7%). No severe complications during and after the procedures were recorded. The main minor complication was vasovagal reaction in 14 patients (5.4%) (Table I).

In terms of treatment success, no significant difference was found according to age, sex, body mass index (BMI), and pre-procedural NRS scores ($p>0.05$). There was no significant difference in the treatment success according to the epidural approaches ($p>0.05$). However, the presence of instrumentation was found to be significantly lower in the group that achieved treatment success ($p=0.045$). Symptom duration and NRS score at 1 hour were found to be significantly lower in the TS group ($p=0.011$, and $p=0.002$). In addition, the use of triamcinolone acetonide in the TS group was found to be significantly higher than in the TF group ($p=0.027$) (Table II). The multivariate binary logistic regression analysis revealed that duration of symptoms, instrumentation, NRS score at 1 hour, and steroid type were the main prognostic factors related to the treatment success (Table III).

Discussion

Due to patient selection and different techniques, it is very challenging to predict the efficacy of ESIs[2]. In addition, peripheral and central nervous system components may complicate the evaluation in patients with chronic pain. Manchikanti et al[1] reported Level I evidence for transforaminal and interlaminar epidural injections and Level II evidence for caudal epidural injections in their meta-analysis. In the present study, we found no

Table I. Demographic and procedural characteristics.

Variable		(n=260)
Age (years), median (min-max)		54.53 (22-92)
BMI (kg/m^2), mean±SD		28.96±4.97
Symptom duration (months), median		19.55 (1-144)
Sex, n (%)	Male	105 (40.4%)
	Female	155 (59.6%)
NRS, mean±SD	Pre-procedural	8.37±1.21
	First hour	1.28±0.21
	First month	3.71±0.30
Treatment success, n (%)	Yes	163 (62.6%)
	No	97 (37.4%)
Instrumentation, n (%)	Yes	71 (27.3%)
	No	189 (72.7%)
Type of ESI, n (%)	Caudal	69 (26.5%)
	TFESI	179 (68.8%)
	ILESI	12 (4.6%)
Steroid type, n (%)	Triamcinolone acetonide	89 (34.3%)
	Betamethasone	171 (65.7%)
Medication, n (%)	Opioid use	62 (23.8%)
	Pregabalin use	85 (32.7%)
	Gabapentin use	56 (21.5%)
	Duloxetine use	40 (15.4%)
Complications, n (%)	Major complications	Not observed
Minor complications	Vasovagal reaction	14 (5.4%)
	Increased pain	5 (1.9%)
	Non-positional headache	3 (1.2%)
	Dural puncture	3 (1.2%)
	Postdural puncture headache	1 (0.3%)

ESI: epidural steroid injection, BMI: body mass index, NRS: Numeric Rating Scale.

Table II. Comparison of groups in terms of treatment success.

	Treatment success group (n=163)	Treatment failure group (n=97)	*p*-value
Age (years)			
<65	49.50±(9.60)	47.26±(9.52)	0.110
>65	70.11±(7.13)	68.05±(11.60)	0.087
*BMI (kg/m^2)	29.20±4.92	28.51±5.06	0.299
Symptom duration (months)	16.64±2.55	24.45±2.79	0.011
Pre-procedural pain (†NRS)	8.29±1.22	8.52±1.51	0.141
First-hour pain (NRS)	0.96±0.13	1.82±0.17	0.002
First-month pain (NRS)	1.75±1.60	7.01±1.66	0.001
¶ESI approach			
Caudal	110 (67.5%)	69 (71.1%)	0.404
Transforaminal	47 (28.8%)	22 (22.7%)	
Interlaminar	6 (3.7%)	6 (6.2%)	
Sex			
Male	65 (39.8%)	40 (41.2%)	0.027
Female	98 (60.2%)	57 (58.8%)	
Steroid			
Betamethasone sodium phosphate/ betamethasone acetate	99 (60.7%)	72 (74.2%)	0.465
Triamcinolone acetonide	64 (39.3%)	25 (25.8%)	
Instrumentation			
Yes	38 (23.3%)	33 (34.0%)	0.045
No	125 (76.7%)	64 (66.0%)	
Oral medication			
Opioid			
Yes	36 (22.0%)	27(27.8%)	0.295
No	127 (78.0%)	70 (72.2%)	
Gabapentinoid			
Yes	83 (50.9%)	57 (58.7%)	0.220
No	80 (49.1%)	40 (41.3%)	

*BMI: body mass index, †NRS: Numeric Rating Scale, ¶ESI: epidural steroid injection.

Table III. Multivariate binary logistic regression analysis results.

	OR	*p*-value	95% CI (Lower to Upper)
Age (years)			
<65	0.968	0.118	0.873-1.122
>65	0.788	0.075	0.676-0.987
BMI (kg/m^2)	1.020	0.520	0.961-1.067
Sex	0.978	0.941	0.532-1.696
Symptom duration (months)	1.018	0.004	1.006-1.029
Pre-NRS	1.191	0.148	0.940-1.509
First-hour NRS	1.200	0.006	1.055-1.366
Steroid type	0.457	0.013	0.246-0.849
Instrumentation	0.485	0.036	0.246-0.956
Type of ESI	0.591	0.144	0.292-1.196
Opioid use	0.823	0.572	0.418-1.618

OR: odds ratio, CI: confidence interval; ESI: epidural steroid injection, BMI: body mass index, NRS: Numeric Rating Scale.

significant difference in treatment success between the approaches of epidural injections in patients undergoing lumbar spinal surgery. Our study results are also consistent with the findings of Celenlioglu et al[15], who reported that caudal and transforaminal epidural injections had similar efficacy in FBSS.

Central sensitization, which is established as a result of prolongation of the symptom duration, may complicate the treatment of chronic pain. The main goal of pain treatment is, therefore, not to completely relieve the pain anymore, but also to control pain[16]. Lee et al[9] found that ESI treatment

yielded more favorable results in patients with pain for less than six months, although it did not reach statistical significance. Ekedahl et al[17] also reported that patients with a shorter duration of leg pain benefited more from transforaminal epidural injections. Unsurprisingly, in the present study, the length of symptom duration reduced the effectiveness of ESI treatment and was a predictive factor for treatment success. These results are consistent with those of Cyteval et al[6] who reported that injections should be administered in the early period.

Obesity has been shown to be a risk factor in the chronicity of mechanical low back pain and may complicate the treatment[18]. However, there is a limited number of evidence about how much it affects ESI treatment outcomes. In only one pilot study, obesity had no effect on the treatment success of epidural injections[19]. In the current study, patients in the groups with and without treatment success had similar BMI values. These results are consistent with the findings reported by McCormick et al[19].

In the current study, patient age did not significantly differ between the groups. Also, sex did not affect the results of ESI treatment. In this respect, our results are consistent with previous studies[6,9,10]. There was also no significant difference in oral medical treatments used between the groups.

In the literature, there is insufficient evidence that one type of steroid is more effective than another for ESI. However, particulate steroids have been shown to increase efficacy as they stay in the pathologic area longer[2]. The complication rate is not high in lumbar procedures, although they increase the risk. Therefore, we use particulate steroids in the lumbar region in our daily practice. In the current study, the use of triamcinolone acetonide was higher in the TS group than in the TF group. Preparations of triamcinolone acetonide and betamethasone sodium phosphate/betamethasone acetate are similar in particle size. However, commercial betamethasone has no particles larger than 500 μ, whereas 3% of particles in triamcinolone are larger than 500 μ and 1% is larger than 1,000 μ[20]. In their study, Derby et al[21] reported that both steroids tended to form aggregates, and the particle size for triamcinolone acetonide was more variable and could reach much larger sizes.

A review of the literature reveals a study[10] reporting that treatment success is higher in patients with high pre-procedural pain in ESI treatment, while there are studies also reporting that it has no effect on the results[6]. In the present study, pre-procedural pain scores were not a criterion for measuring treatment success.

In a study, Şencan et al[22] reported that a decreased pain score at 1 hour was a predictor for a favorable three-month response to transforaminal ESI. In the current study, the degree of pain relief at 1 hour after the procedure was higher in the TS group. Therefore, we believe that early pain reduction is a positive predictor of short-term prognosis.

In the present study, spinal surgery was classified into two groups according to the presence of instrumentation. Accordingly, those who did not have instrumentation had higher rates of success in treatment. It is unclear whether this difference is attributable to the pathologies that led to spinal instrumentation. Complex conditions such as recurrent spinal stenosis with instability, degenerative spondylolisthesis, and spinal gunshot injuries, which have increased in recent years[23], are conditions where instrumentation is preferred. It should be kept in mind that instrumented patients mostly have multi-level and different pathologies[23,24]. Furthermore, a centralized pain process may be more responsible than a peripheral process for those patients. Regardless of the cause, we believe that instrumented individuals benefit less from ESI treatment. This is also consistent with previous studies[25] that have compared different surgical techniques. For instance, Hu et al[25] reported that the percutaneous endoscopic lumbar discectomy (PELD) group was associated with lower visual analog scales (VAS) scores for back pain, and lower Oswestry Disability Index (ODI) scores than the minimally invasive transforaminal lumbar interbody fusion group.

There are many reasons why pain in FBSS continues after surgery. These include inappropriate patient selection (e.g., axial low back pain), incorrect level of surgery, poor technique, incomplete surgical procedures, post-surgical epidural fibrosis, recurrent herniation, and psychosocial factors[12]. In the present study, we examined patients with lumbar radicular pain and excluded those with axial low back pain and major psychiatric disorders, which may be one of the causes of FBSS. In their study, Celenlioglu et al[15] attributed the partially low success rates to their application in patients with epidural fibrosis. We routinely perform hyaluronidase injections besides the epidural injections for patients with epidural fibrosis. Therefore, we also excluded those patients. The reason for the ongoing radicular pain could be the incorrect level of surgery, incomplete surgical procedures, or recurrent herniation. We were not able to investigate this issue. Therefore, a subgroup analysis was not performed. Although we believe

that the reasons listed would not affect the results, it may be considered a limitation of the study.

As our study has a single-center, retrospective design, we could not access magnetic resonance (MR) imaging scans of many patients. Therefore, we could not evaluate parameters such as the grade of nerve root compression, and the location or size of the disc herniation, as some studies[5,7,8] in non-operated patients. This can be regarded as a limitation of this study. However, we would like to emphasize that the decisions regarding the procedures were made subsequent to the evaluation of MR images. The reason for the unattainability of accessing these images stems from their absence in the system records.

Another limitation of the present study is that no subgroup analysis was performed for the ESI applied levels. However, we have strict criteria for ESI applications in operated patients in our clinic. We prefer transforaminal injections in pathologies involving one or two nerve roots and caudal or interlaminar injections in multiple nerve root pathologies. We avoid interlaminar injections in patients undergoing surgery, due to the high risk of complications. However, we also apply to these procedures below or above the level of previous surgery, particularly in pathologies above the L4/5 level. For single-level transforaminal epidural injections, 40 mg of triamcinolone acetonide or 3 mg of betamethasone sodium phosphate/betamethasone acetate are used. For two-level transforaminal ESI, caudal, and interlaminar epidural injections, 80 mg of triamcinolone acetonide or 6 mg of betamethasone sodium phosphate/betamethasone acetate are used. Due to our standards, in the patients included in the current study, the approaches we opted for and the doses we administered were as indicated.

In our study, the number of patients with long-term follow-up is relatively low. Many patients who underwent ESI did not attend to their follow-up, particularly after the first month. To identify the predictive factors, we included the first-month follow-ups in the study, as our primary objective was to keep the number of patients high. Obviously, this situation cannot be counted among the strengths of the study. However, many valuable studies investigating predictive factors in ESI treatments in non-operated patients have similar follow-up periods, such as one month or less[7,9,10].

Conclusions

In conclusion, ESI is an effective treatment method providing pain relief in patients undergoing lumbar spinal surgery. The short duration of symptoms and the absence of instrumentation can be shown as prognostic factors that positively affect the success of ESI treatment in operated patients. The steroid type can also change the results. In addition, ≥50% pain reduction in the first hour after the procedure is a valuable indicator that treatment success can be achieved in the short term.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Informed Consent

The authors declare that the patients included in the study signed informed consent forms to use their medical information in the studies.

Ethics Approval

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Ethics Committee of Marmara University Faculty of Medicine, Istanbul, Turkey, with Approval No.: 09.2023.357.

Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Authors' Contributions

Conceptualization, S.K., Y.O., R.S., and S.S.; Methodology, S.K., R.S., S.S., and O.H.G.; Data curation, S.K., R.S, and Y.O.; Formal Analysis, S.K., R.S., and O.H.G.; Investigation, S.K., R.S., Y.O., and S.S.; Writing-original draft, S.K., R.S.; Writing-review and editing, Y.O., S.S., and O.H.G.; Project administration, S.K., S.S.; Supervision, O.H.G. All authors have read and agreed to the published version of the manuscript.

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References

1) Manchikanti L, Knezevic E, Knezevic NN, Vangala BP, Sanapati MR, Thota S, Abdi S, Abd-Elsayed A, Kaye AD, Hirsh JA. A Comparative Systematic Review and Meta-Analysis of 3 Routes of Administration of Epidural Injections in Lumbar Disc Herniation. Pain Physician 2021; 24: 425-440.
2) Friedrich JM, Harrast MA. Lumbar epidural steroid injections: indications, contraindications, risks, and benefits. Curr Sports Med Rep 2010; 9: 43-49.
3) Lee JH, Lee SH. Clinical effectiveness of percutaneous adhesiolysis versus transforaminal epidural steroid injection in patients with postlumbar surgery syndrome. Reg Anesth Pain Med 2014; 39: 214-218.
4) Manchikanti L, Singh V, Cash KA, Pampati V, Datta S. Fluoroscopic caudal epidural injections in managing post lumbar surgery syndrome: two-year results of a randomized, double-blind, active-control trial. Int J Med Sci 2012; 9: 582-591.
5) Choi SJ, Song JS, Kim C, Shin MJ, Ryu DS, Ahn JH, Jung SM, Park MS. The use of magnetic resonance imaging to predict the clinical outcome of non-surgical treatment for lumbar intervertebral disc herniation. Korean J Radiol 2007; 8: 156-163.
6) Cyteval C, Fescquet N, Thomas E, Decoux E, Blotman F, Taourel P. Predictive factors of efficacy of periradicular corticosteroid injections for lumbar radiculopathy. AJNR Am J Neuroradiol 2006; 27: 978-982.
7) Ghahreman A, Bogduk N. Predictors of a favorable response to transforaminal injection of steroids in patients with lumbar radicular pain due to disc herniation. Pain Med 2011; 12: 871-879.
8) Lee JW, Choi SW, Park SH, Lee GY, Kang HS. MR-based outcome predictors of lumbar transforaminal epidural steroid injection for lumbar radiculopathy caused by herniated intervertebral disc. Eur Radiol 2013; 23: 205-211.
9) Lee JW, Kim SH, Lee IS, Choi JA, Choi JY, Hong SH, Kang HS. Therapeutic effect and outcome predictors of sciatica treated using transforaminal epidural steroid injection. AJR Am J Roentgenol 2006; 187: 1427-1431.
10) McCormick Z, Cushman D, Casey E, Garvan C, Kennedy DJ, Plastaras C. Factors associated with pain reduction after transforaminal epidural steroid injection for lumbosacral radicular pain. Arch Phys Med Rehabil 2014; 95: 2350-2356.
11) Um MK, Lee E, Lee JW, Kang Y, Ahn JM, Kang HS. Fluoroscopic lumbar transforaminal epidural steroid injections for recurrent herniated intervertebral disc after discectomy: Effectiveness and outcome predictors. PLoS One 2022; 17: e0271054.
12) Chan CW, Peng P. Failed back surgery syndrome. Pain Med 2011; 12: 577-606.
13) Bicket MC, Chakravarthy K, Chang D, Cohen SP. Epidural steroid injections: an updated review on recent trends in safety and complications. Pain Manag 2015; 5: 129-146.
14) MacVicar J, King W, Landers MH, Bogduk N. The effectiveness of lumbar transforaminal injection of steroids: a comprehensive review with systematic analysis of the published data. Pain Med 2013; 14: 14-28.
15) Celenlioglu AE, Sencan S, Bilim S, Sancar M, Gunduz OH. Comparison of Caudal Versus Transforaminal Epidural Steroid Injection in Post Lumbar Surgery Syndrome After Single-level Discectomy: A Prospective, Randomized Trial. Pain Physician 2022; 25: 161-169.
16) Cohen SP, Vase L, Hooten WM. Chronic pain: an update on burden, best practices, and new advances. Lancet 2021; 397: 2082-2097.
17) Ekedahl H, Jönsson B, Annertz M, Frobell RB. The 1-Year Results of Lumbar Transforaminal Epidural Steroid Injection in Patients with Chronic Unilateral Radicular Pain: The Relation to MRI Findings and Clinical Features. Am J Phys Med Rehabil 2017; 96: 654-662.
18) Knezevic NN, Candido KD, Vlaeyen JWS, Van Zundert J, Cohen SP. Low back pain. Lancet 2021; 398: 78-92.
19) McCormick Z, Plastaras C. Lumbosacral transforaminal epidural steroid injections are equally effective for treatment of lumbosacral radicular pain in the obese compared to non-obese population: a pilot study. J Back Musculoskelet Rehabil 2013; 26: 183-188.
20) Benzon HT, Chew TL, McCarthy RJ, Benzon HA, Walega DR. Comparison of the particle sizes of different steroids and the effect of dilution: a review of the relative neurotoxicities of the steroids. Anesthesiology 2007; 106: 331-338.
21) Derby R, Lee SH, Date ES, Lee JH, Lee CH. Size and aggregation of corticosteroids used for epidural injections. Pain Med 2008; 9: 227-234.
22) Şencan S, Çelenlioğlu AE, Asadov R, Gündüz OH. Predictive factors for treatment success of transforaminal epidural steroid injection in lumbar disc herniation-induced sciatica. Turk J Med Sci 2020; 50: 126-131.
23) Villarreal-García FI, Martínez-Gutiérrez OA, Reyes-Fernández PM, Saavedra-Badillo LA, Avalos RM, Acosta-Olivo CA, Pena-Martínez VM. Two-year prevalence of spinal gunshot injuries in Mexico: A single center experience. Cir Cir 2022; 90: 467-472.
24) Omidi-Kashani F, Hasankhani EG, Ashjazadeh A. Lumbar spinal stenosis: who should be fused? An updated review. Asian Spine J 2014; 8: 521-530.
25) Hu ZX, Han J, Sun YF, Tian XL. Comparison of percutaneous endoscopic lumbar discectomy vs. minimally invasive transforaminal lumbar interbody fusion for the treatment of single-segment lumbar disc herniation: a meta-analysis. Eur Rev Med Pharmacol Sci 2022; 26: 6678-6690.