Incidence and Factors that Affect Anterior Sacral Foramen Leakage in Fluoroscopically Guided Caudal Epidural Steroid Injection

[1,*]Chan Hong Park, [1]Hyen Jun Kim and [2]Sang Ho Lee

[1]Department of Anesthesiology and Pain Medicine, Wooridul Spine Hospital, Daegu, South Korea, [1]Department of Neurosurgery, Wooridul Spine Hospital, Daegu, South Korea, [2]Department of Neurosurgery, Wooridul Spine Hospital, Seoul, South Korea

Abstract: ***Background*:** During the caudal epidural steroid injection (CESI), sacral foramen leakage can occur. The aim of this study was to evaluate incidence and the correlation of anterior sacral foramen leakage with several factors. ***Methods*:** We retrospectively analyzed the medical records of patients who underwent CESI. The epidural needle position and sacral foramen leakage (yes or no) in C-arm view were recorded. The following parameters were measured: 1) depth of the intervertebral disc at S1-S2, S2-S3, and S3-S4; 2) distances between the posterior borders of S1 and the apex of the sacral hiatus; and 3) depths of S1, S2 the sacral canal. ***Results*:** Ninety-one subjects were evaluated. The patients were predominately women (60%) with a mean age of 65.5 ± 11.6 years. There was leakage in 58% (53/91) of patients. One-level leakage occurred in the largest proportion of patients (27%). Age, gender, needle tip position, the depth of the intervertebral disc at S1-S2, S2-S3, and S3-S4, the distances between the posterior borders of S1 and the apex of the sacral hiatus, and the depths of S1, S2 the sacral canal were not correlated with sacral foramen leakage. ***Conclusion*:** We found leakage in 58% of patients regardless of age, gender, needle-tip position, the depth of the intervertebral disc at S1-S2, S2-S3, and S3-S4, the distances between the posterior borders of S1 and the apex of the sacral hiatus, and the depths of S1, S2 the sacral canal. Therefore, clinicians should be aware that leakage can occur in any circumstance.

Keywords: incidence, factors, anterior, sacral, foramen, leakage, fluoroscopically, caudal, epidural, steroid, injection.

INTRODUCTION

Caudal epidural steroid injections (CESI) are commonly administered to help reduce radicular pain in patients with low back pain (1-3). Studies have been conducted to evaluate the effectiveness of this procedure with fluoroscopic guidance (4, 5). Several of these studies have demonstrated the effectiveness of fluoroscopically guided caudal epidural injections in patients with degenerative lumbar spinal stenosis or post-lumbar surgery syndrome (1, 3, 6).

CESI is performed by inserting a needle through the sacral hiatus and delivering medication into the epidural space. The procedure is safe and simple and is therefore used more often than a lumbar epidural block during outpatient treatment (7).

To increase the success rate of CESI, the exact procedure is important. A previous study found that the failure rate for the traditional CESI technique can be as high as 25% (8). This high failure rate may be related to inaccurate needle placement and failure of the therapeutic agents to flow (8). To reduce the probability of malposition for the caudal needle, C-arm fluoroscopy and/or ultrasonography (US) can be used (7, 9).

Despite the use of C-arm and/or US during the procedure, inaccurate needle placement, blood regurgitation, and vascular injection can still occur (10). In addition, leakage into the sacral foramen has been reported (10-12). If a large leak develops, a large volume will be needed to ensure the drug reaches the painful region. To reach the target area for the drug, the anteroposterior distance of the sacral canal and the distance from the apex of the sacral hiatus to the S2 foramen are important (13). Ogoke et al (11) reported that the volume needed to reach the L5 level is 10 ml and the corresponding amount for the L4 level is 15 ml (11).

*Address correspondence to this author at the Department of Anesthesiology and Pain Medicine, Wooridul Spine Hospital, Daegu, South Korea; Email: magary1@hanmail.net; Tel: 82-53-212-3179

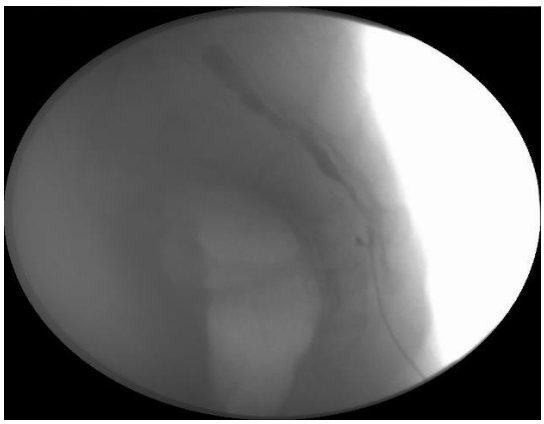
The aim of this study was to evaluate incidence and the correlation of anterior sacral foramen leakage with age, gender, needle tip position, the depth of the sacral intervertebral disc at S1-S2, S2-S3, and S3-S4, the distances between the posterior borders of S1 and the apex of the sacral hiatus, and the depths of S1, S2 sacral canal.

METHODS

This study was approved by the Institutional Review Board of our hospital. We retrospectively analyzed the medical records of patients who underwent CESI between January 2019 and December 2019 due to low back pain and or radicular pain.

The procedures were performed by a single anesthesiologist who had >20 years of experience with CESI. The patients were placed in the prone position on the fluoroscopic table. Betadine and alcohol were used to sterilize the procedure site and the patient was draped so the sacral hiatus area could be exposed. The sacral hiatus was detected by palpation. A skin wheal was made over the sacral hiatus using a 25-gauge needle with 2% lidocaine and a 22-gauge 10-cm Tuohy needle was inserted into the sacral canal using the C-arm lateral view. The Tuohy needle bevel was pointed toward the dorsal space. If the needle was correctly placed, 3 mL of contrast was administered to confirm cephalad flow of the dye to the targeted level under the anteroposterior (AP) fluoroscopic view. Images were also obtained in the C-arm lateral view. A mixture of 3 mL of 2% lidocaine, 5 mg dexamethasone, 1500 IU hyaluronidase, and normal saline (total volume 16 mL) was injected if the dye reached the L5-S1 level.

The epidural needle tip position and sacral foramen leakage (yes or no) in C-arm view were recorded. Leakage type was defined as follows: A, indicated half leakage at only one level in the sacrum, B indicated one-level leakage, C indicated one-level leakage and half leakage at another level, and D indicated full leakage at two levels in the sacrum (Figure **1**). All patients who had a CESI with a mid-sagittal computed tomography (CT) view were reviewed



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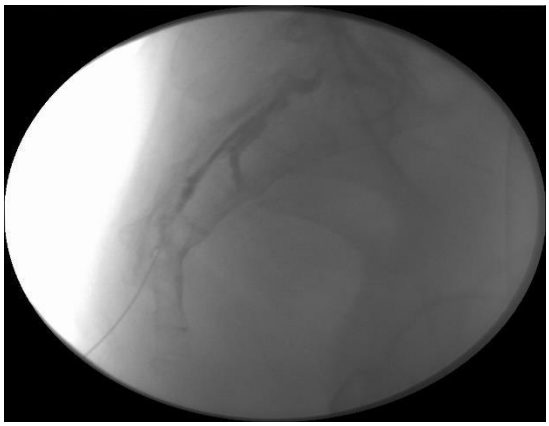

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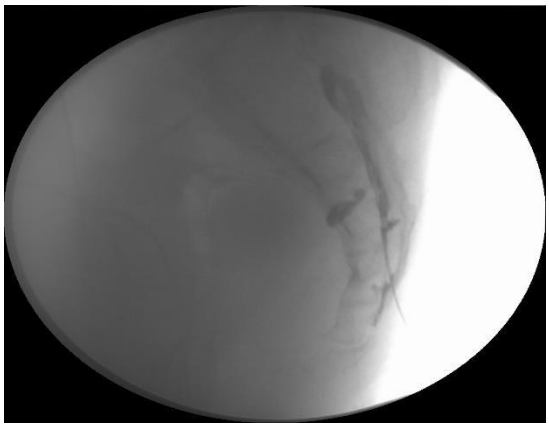

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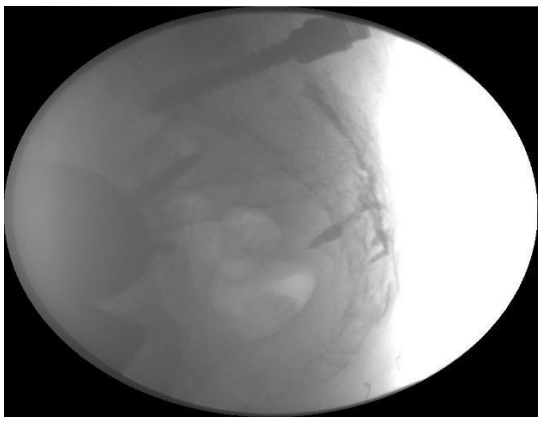

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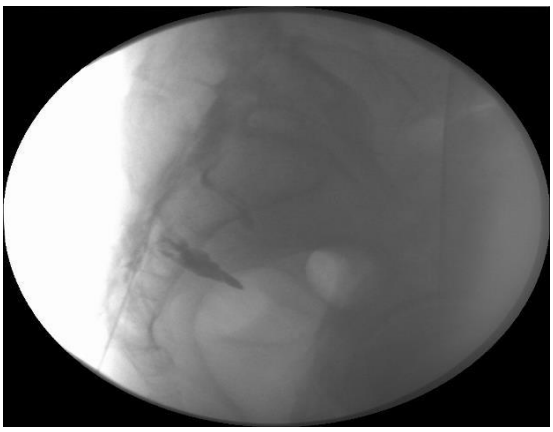

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Figure 1: (A). No leakage into anterior sacral foramen, (B). A as half leakage of sacrum at one level, (C). B one level leakage seen in C-arm view, (D). C was 1 level leakage and half leakage of another level, and (E) D was 2 level full leakage of sacrum.

and the following parameters were measured: 1) depth of the sacral intervertebral disc at S1-S2, S2-S3, and S3-S4 (Figure **2**), 2) distances between the posterior borders of S1 and the apex of the sacral hiatus (Figure **3**), 3) depths of S1, S1 sacral canal (Figure **4**).

As statistical measures, the independent t-test, chi-square test, Fisher's exact test, and univariate logistic regression were performed with the significance set at $p<0.05$.

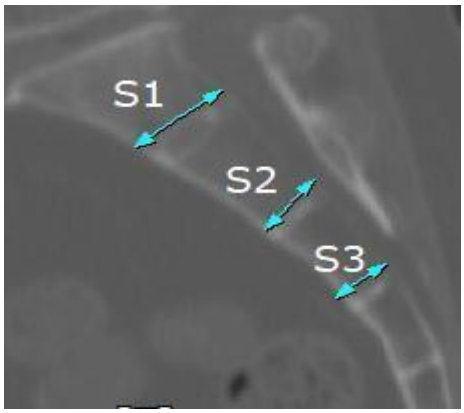

Figure 2: The depth of sacral intervertebral disc at S1-S2, S2-S3 and S3-4 was measured.

Figure 3: The distance between posterior border of S1 and apex of sacral hiatus was measured.

Figure 4: The depth of S1, and S2 sacral canal was measured.

RESULTS

Ninety-one subjects were evaluated. The patients were predominately women (60%) with a mean age of 65.5 ± 11.6 years (Table **1**). S1-2 sacral intervertebral disc depth was most longest. S3 foramen and the levels below were the most common site for the epidural needle tip position.

Table 1: Data from subjects.

N=91	Mean ± MD
Age (yrs)	65.5 ± 11.6
Depth of S1-S2 intervertebral disc (mm)	25.3 ± 22.6
Depth of S2-S3 intervertebral disc (mm)	15.6 ± 3.1
Depth of S3-4 intervertebral disc (mm)	11.8 ± 2.5
Depth of S1 canal (mm)	10.5 ± 2.1
Depth of S2 canal (mm)	6.9 ± 1.5
Distance between S1 – apex of sacral hiatus (mm)	75.3 ± 18.7
N=91	frequency
Gender (M : F)	31 : 60
Position of epidural needle tip	
Below S3 foramen	1
At S3 foramen	80
Between S2-S3 foramen	10

There was leakage in 58% (53/91 patients) of patients. One-level leakage was the most common and was observed in 27% of patients, followed by half leakage in the sacrum (Table **2**).

Table 2: Frequency of anterior sacral foramen leakage.

N=91	Frequency
Leakage	
No	38 (41.8%)
Yes	53 (58.2%)
Leakage type (n=53)	
A	15 (16.5%)
B	25 (27.5%)
C	2 (2.2%)
D	11 (12.1%)

Leakage type: A indicated half leakage at only one level in the sacrum, B indicated one-level leakage, C indicated one-level leakage and half leakage at another level, and D indicated full leakage at two levels in the sacrum

Between no leakage subjects and leakage patient, there was significant difference in age, depth of S1-S2, S2-S3, S3-S4 intervertebral disc, S1 canal and, S2 canal, and distance between S1-apex of sacral hiatus (Table **3**).

Table 3: Comparison of between no sacral foramen leakage and leakage subjects.

N=91	No Leakage (n=38)	Leakage (n=53)	P value
Age	63.9 ± 13,4	66.5 ± 10.1	0.292
Depth of S1-S2 IVD (mm)	27.9 ± 4.7	23.4 ± 4.3	0.501
Depth of S2-S3 IVD (mm)	15.2 ± 3.3	16.0 ± 3.3	0.247
Depth of S3-S4 IVD (mm)	11.5 ± 2.8	12.1 ± 2.3	0.247
Depth of S1 canal (mm)	10.3 ± 2.2	10.8 ± 2.1	0.304
Depth of S2 canal (mm)	6.9 ± 1.7	6.8 ± 1.7	0.690
Distance between S1 – apex of sacral hiatus (mm)	73.5 ± 4.5	74.6 ± 4.1	0.454

IVD: intervertebral disc

Age, gender, epidural needle tip position, the depth of the sacral intervertebral disc at S1-S2, S2-S3, and S3-S4, the distances between the posterior borders of S1 and the apex of the sacral hiatus, and the depths of S1, S2 the sacral canal were not correlated with anterior sacral foramen leakage (Table **4**).

Table 4: Correlation leakage with variable factors.

N=91	B	Beta	P value
Age	0.004	0.099	0.368
Gender	0.155	0.141	0.275
Position of needle tip position	-0.291	-0.098	0.372
Depth of sacral intervertebral disc			
S1-S2	-0.003	-0.136	0.210
S2-S3	0.036	0.225	0.355
S3-S4	0.013	0.068	0.780
Distance of between S1 and sacral hiatus	-0.004	-0.154	0.191
Depth of S1 canal	0.036	0.154	0.228
Depth of S2 canal	-0.038	-0.118	0.348

DISCUSSION

In our study, sacral foramen leakage occurred in 58% of patients. 58%. And, age, gender, needle tip position, the depth of the sacral intervertebral disc at S1-S2, S2-S3, and S3-S4, the distances between the posterior borders of S1 and the apex of the sacral hiatus, and the depths of S1, S2 the sacral canal were not correlated with anterior sacral foramen leakage.

In generally, the mean volume of the sacral canal is 38 ml (23-62 ml) and the mean volume of the caudal space is 14 ml (6.67-24 ml) (14). To approach at target area with the

optimal amount for drug delivery, the drug may be reduced intravascular injection or sacral foramen leakage. In our study, sacral foramen leakage was not related any factors.

In our study, the epidural needle tip was placed below the S2-S3 sacral intervertebral disc level. Therefore, a dural puncture did not occur because the dural sac ends at S2 (15). The epidural needle tip was placed at the midline of the sacrum in our study. The needle tip position (midline or lateral) during CESI is not related to the epidural spreading pattern at the L4-5 and L5-S1 disc levels. Further, the direction of the needle bevel was dorsal in our study. The bevel direction (ventral or dorsal) is also not related to the epidural spreading pattern at the L4-5 and L5-S1 disc levels (16). A 22-gauge Tuohy epidural needle was used in our study. Sim et al (17) reported that the needle gauge (23 gauge vs. 20 gauge vs. 17 gauge) did not influence the caudal epidural spread.

The distance between the apex of the sacral hiatus and posterior border of S1 foramen is an important factor in the success of CESI (13). In our study, the distance between the apex of the sacral hiatus and S1 foramen was not correlated with sacral foramen leakage. The mean distance was 77 mm in our study and in a similar previous study (13).

The respective depths of the sacral intervertebral disc at S1/S2 and S2/S3 were 10 mm and 7 mm in our study. The depth of the sacral canal did not correlate with leakage. We had assumed that more leakage would occur with a smaller depth.

There were some limitations. First, this study is a retrospective study and few participants were included. Second, leakage can be affected by various factors such as the sacral foramen size. Third, the fluoroscopic images were assessed by two physicians. However, bias may have occurred during the analysis of the radiologic images. Finally, we did not evaluate the relationship between the sacral leakage and patient outcomes.

CONCLUSION

In conclusion, we found leakage in 58% of patients regardless of age, gender, needle tip position, the depth of the intervertebral disc at S1-S2, S2-S3, and S3-S4, the distances between the posterior borders of S1 and the sacral hiatus, and the depths of S1, S2 the sacral canal. Therefore, clinicians should be aware that leakage can occur in any circumstance.

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