

Original Article

Influence of hanging height of saline bag in flushing of percutaneous transforaminal endoscopic lumbar discectomy on spinal cord hypertension syndrome

Xingwei Pu, Lihang Wang, Tingsheng Lu, Shudan Yao, Jianwen Yang, Chunshan Luo

Department of Spinal Surgery, Orthopaedic Hospital of Guizhou Province, Guiyang, Guizhou Province, China

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Abstract: Objective: To investigate the effect of hanging height of saline bag in flushing percutaneous transforaminal endoscopic lumbar discectomy on spinal cord hypertension syndrome. Methods: Altogether 100 patients with lumbar disc herniation were selected as research participants and divided into group A, group B, group C, and group D by random number grouping method. The grouping standard was the hanging height of saline bag during operation of 60 cm, 70 cm, 80 cm and 90 cm respectively. Intraoperative somatosensory evoked potential (SEP) + electromyography (EMG) + transcranial electrical stimulation motor evoked potential (TCe MEP), postoperative incidence of spinal cord hypertension, Oswestry disability index (ODI) score and Mac Nab efficacy 3 months after surgery were observed. Results: The results of monitoring SEP+MEP+EMG in the four groups of patients revealed that the positive rate of SEP+MEP+EMG in group C and group D was significantly higher than that in group A and group B ($P < 0.05$ or $P < 0.001$). The incidence of postoperative spinal cord hypertension in the four groups of patients showed that the incidence of spinal cord hypertension in group C and group D was significantly higher than that in group A and group B ($P < 0.05$ or $P < 0.001$). ODI score 3 months after surgery in group B was lower than that in group A, group C, and group D, and the score in group A was lower than that in group D ($P < 0.05$). The curative effect of Mac Nab 3 months after operation showed that the excellent and good rate in group B was higher than that in group A, group C, and group D ($P < 0.05$ or $P < 0.01$). Conclusion: The occurrence of spinal cord hypertension during PELD through intervertebral approach under continuous epidural anesthesia is related to the hanging height of saline bag. The hanging height of saline bag is related to the possibility of spinal cord-like hypertension. It is ideal when the hanging height of saline bag is about 70 cm.

Keywords: PELD, hanging height of saline bag, spinal cord hypertension syndrome, correlation study

Introduction

Lumbar disc herniation (LDH) is caused by rupture of the annulus fibrosus in the lumbar disc, and the nucleus pulposus in the annulus fibrosus protrudes from the back or inside the spinal canal, thus causing compression on the local spinal nerve roots and causing the lumbar pain. The location is mostly from lumbus 5 to sacrum 1 [1, 2]. For LDH patients, medication and rest conservative treatment are usually selected, and most symptoms can be relieved [3]. But there are still some patients whose clinical symptoms cannot be relieved, so they need surgical intervention treatment [4]. With the development of technology, surgical treatment programs for LDH also tend to be mini-

mally invasive, and intervertebral foramen endoscopy plays an important role in the treatment of LDH patients. Percutaneous transforaminal endoscopic lumbar discectomy is recommended for the treatment of LDH due to its small trauma and good curative effect [5], in which percutaneous endoscopic lumbar discectomy (PELD) is one of the choices. As it can resect part of ligamentum flavum and effectively remove nucleus pulposus, its curative effect is better. Compared with percutaneous lumbar intervertebral foramen, PELD is easy to puncture and reduce the difficulty and risk of operation [6], but we found in clinical application that PELD operation is prone to spinal cord hypertension and the incidence rate is about 7-10%, which is higher than other operative methods.

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Spinal cord hypertension [7] refers to discomfort such as head and neck pain, neck stiffness, nausea, vomiting, and even dysphoria, elevated blood pressure, and increased heart rate during lumbar intervertebral foramen endoscopic surgery. In clinical practice, most of them were found in PELD through transpedicular approach, and the specific cause is still unclear. This situation brings great pain to the patients and also becomes a difficult problem in the diagnosis and treatment processes of spine surgeons. Joh et al. proposed that cervical pain is highly correlated with the increase of cervical epidural pressure and flushing velocity, and is likely to be accompanied by the up-regulation of intracranial pressure [8]. Studies by Yan and others have shown that cervical pain is related to high cervical epidural pressure [9]. However, the authors found in clinic that the hanging height of saline bag during PELD via the intervertebral approach was related to the high probability of occurrence of spinal cord hypertension. Based on this, the influence of the intraoperative hanging height of saline bag on spinal cord hypertension syndrome was studied. The participants were grouped according to the hanging height of saline bag under the condition that other indicators were consistent. In addition, somatosensory evoked potential (SEP) + electromyography (EMG) + transcranial electrical stimulation motor evoked potential (TCe MEP), and multi-mode neurophysiological monitoring (ONM) were used to determine whether the hanging height of saline bag was related to postoperative spinal cord hypertension in patients with intraoperative spinal cord nerve changes. At present, there is no corresponding research report at home and abroad, and Oswestry dysfunction index (ODI) and Mac Nab efficacy evaluation were monitored. ODI reflected the influence of waist and leg pain on patients' daily activities, and the reliability was as high as 0.95 after repeated tests [10]. Mac Nab curative effect is an important indicator for evaluating lumbar spine function [11]. This study monitored the above two indicators and observed the postoperative recovery. The report is as follows.

Materials and methods

General data

A prospective study was conducted on 100 patients with lumbar disc herniation admitted

to Orthopaedic Hospital of Guizhou Province from December 2016 to December 2018, including 62 males and 38 females, aged 34-72 years, with an average age of 52.0 ± 7.8 years. The patients were divided into group A, group B, group C, and group D by random number grouping method. The grouping standard was the hanging height of saline bag during surgery at 60 cm, 70 cm, 80 cm and 90 cm respectively [9]. The study had been approved by the hospital ethics committee and all the patients have signed the informed consent form.

Inclusion and exclusion criteria

Inclusion criteria: According to the diagnostic criteria for lumbar disc herniation [12], all patients underwent PELD operation; patients with waist pain accompanied by numbness of lower limbs and radiation pain in legs; patients had taken conservative drug therapy for 3 months and had poor results; patients had complete clinical data and could cooperate with the follow-up.

Exclusion criteria: Patients had other lesions in spinal canal or spine; patients had calcification of lesion site; patients had changes in the operation or changes of the type of operations; patients suffered from serious heart, liver, kidney and other diseases; patients had difficulty or inconvenience in follow-up.

Methods

All patients underwent PELD surgery, and intraoperative hanging height of saline bag was adjusted to 60 cm, 70 cm, 80 cm and 90 cm respectively according to different groups, with 25 patients in each group. During the operation, somatosensory evoked potential (SEP) + electromyography (EMG) + transcranial electrical stimulation somatic motor evoked potential (TCe MEP) and multimodal neuroelectrophysiology were used to monitor the changes of spinal cord nerve in patients. SEP+MEP+EMG multimodal neuroelectrophysiology was used to monitor the changes of amplitude and latency in each patient, of which SEP and MEP were monitored simultaneously in upper and lower limbs (SEP stimulation sites): median nerve of upper limb, posterior tibial nerve of lower limb; recording sites: median nerve (C3, C4), posterior tibial nerve (Cz), and reference electrode was placed in forehead Fpz; MEP stimulation

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site: 2 cm in front of C3 and C4; recording site: upper limb was contralateral abductor pollicis brevis and lower limb was contralateral tarsal adductor. EMG was mainly monitored in quadriceps femoris and tibialis anterior muscle. At the same time, 10/20 international electrode placement system was used, EMG was used to continuously record muscle resting electrical activity. The monitoring baseline of SEP and MEP was recorded, the changes of amplitude and latency were measured during operation, and EMG was used to continuously record muscle resting electrical activity. Attention was paid to the application of spontaneous electromyography to continuously monitor the peak value, waveform and number of motor units of EMG. At the same time, the changes of electrophysiological amplitude and latency were measured respectively. The intervertebral foramen endoscopic was inserted into the intervertebral lumbar canal and connected with flushing fluid for continuous flushing. The herniated disc nucleus pulposus was removed and the nerve root was released. If continuous EMG spontaneous potentials occurred during the monitoring process, the amplitude and latency of SEP or MEP signals did not meet the warning standard, and the patient had no discomfort symptoms, the operation was continued.

Outcome measures

IONM was used to set up an early warning standard. SEP early warning standard: if the amplitude decreased by more than 50% and/or the incubation period extended by more than 10%, which indicates positive; MEP early warning standard: if the amplitude dropped more than 80%, it indicates positive; EMG early warning standard: the electric activity waveform with high frequency burst was positive. If one of the above items was positive, it indicates positive [13].

Incidence rate of spinal cord hypertension syndrome: head and neck pain, neck stiffness, nausea, vomiting and other discomfort, even dysphoria, elevated blood pressure, increased heart rate and other manifestations during lumbar intervertebral foramen mirror surgery could be judged as spinal cord hypertension syndrome [7].

Oswestry dysfunction index (ODI) score 3 months after surgery: ODI consisted of 10

questions, with the highest score of 5 points for each question. The low score was related to better postoperative recovery [14].

Mac Nab efficacy evaluation standard was used to evaluate the efficacy of 3 months after operation, which could be divided into excellent and moderate difference [11], and the calculation formula was: excellent rate = (excellent + good)/total cases × 100%.

Statistical methods

SPSS 22.0 was used for data analysis and processing. Continuous variable data conforming to normal distribution were expressed by mean ± standard deviation ($\bar{x} \pm sd$). One-way ANOVA was used to detect whether there were significant differences in multiple groups, which was expressed as F. Bonferroni method was further used to carry out post hoc pair-wise comparison. The data that did not conform to the normal distribution and variance homogeneity were expressed by rank sum test, while the counting data were expressed by % and analyzed by Pearson chi-square test, which was expressed by χ^2 . The difference was statistically significant with $P < 0.05$.

Results

Comparison of general data and baseline data of four groups of patients

All patients were followed up for 3 months after the surgery. There was no statistical difference in age, sex, intraoperative blood loss, operation time and length of stay among the four groups ($P > 0.05$). See **Table 1**.

Comparison of intraoperative SEP+MEP+EMG monitoring in four groups of patients

The comparison of the monitoring results of SEP+MEP+EMG in the four groups of patients showed that the positive rate of SEP+MEP+EMG monitoring in group C and group D was higher than that in group A and group B ($P < 0.05$ or $P < 0.001$). See **Table 2** and **Figure 1**.

Comparison of incidence of postoperative spinal cord hypertension in four groups of patients

Comparing the incidence of postoperative spinal cord hypertension in the four groups of

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Table 1. Comparison of general data and baseline data of four groups of patients ($\bar{x} \pm sd, n$)

Items	Group A (n=25)	Group B (n=25)	Group C (n=25)	Group D (n=25)	χ^2/F	P
Gender					0.170	0.982
Male	16	15	15	16		
Female	9	10	10	9		
Age (year)	52.3±7.6	50.7±9.5	52.9±7.5	51.6±8.2	0.330	0.804
Intraoperative blood loss (mL)	57.23±15.34	56.89±16.93	60.23±20.12	58.37±18.23	0.180	0.910
Operation time (min)	70.45±25.33	72.93±26.90	71.23±26.89	70.18±24.76	0.057	0.982
Length of stay (d)	6.59±2.43	6.98±2.65	7.13±2.74	6.99±2.53	0.201	0.896

Note: Group A: the hanging height of saline bag at 60 cm; group B: the hanging height of saline bag at 70 cm; group C: the hanging height of saline bag at 80 cm; group D: the hanging height of saline bag at 90 cm.

Table 2. Comparison of intraoperative SEP+MEP+EMG monitoring in four groups of patients (n, %)

Group	SEP+MEP+EMG monitoring	
	Positive (n, %)	Negative (n, %)
Group A (n=25)	0 (0.00%)	25 (100.00%)
Group B (n=25)	0 (0.00%)	25 (100.00%)
Group C (n=25)	5 (20.00%)*,#	20 (80.00%)
Group D (n=25)	10 (40.00%)*,###	15 (60.00%)
χ^2	21.569	
P	<0.001	

Note: Compared with group A, *P<0.05, ***P<0.001; compared with group B, #P<0.05, ###P<0.001. Group A: the hanging height of saline bag at 60 cm; group B: the hanging height of saline bag at 70 cm; group C: hanging height of saline bag at 80 cm; group D: hanging height of saline bag at 90 cm. SEP+MEP+EMG: somatosensory evoked potential (SEP) + electromyography (EMG) + transcranial electrical stimulation motor evoked potential (Tc MEP).

patients, it was found that the incidence of spinal cord hypertension in group C and group D was higher than that in group A and group B (P<0.05 or P<0.001). See **Table 3**.

Comparison of ODI score of four groups of patients 3 months after operation

The comparison of ODI scores in 3 months after operation showed that group B had lower ODI scores than group A, group C, and group D, and the score of group A was lower than that of group D (all P<0.05). See **Table 4**.

Comparison of curative effect evaluation of Mac Nab in four groups of patients

The comparison of curative effect evaluation of Mac Nab 3 months after operation showed that the excellent and good rate in group B was high-

er than that in group A, group C, and group D (P<0.05 or P<0.01). See **Table 5**.

Discussion

Common complications of intervertebral foramen endoscopy are nerve injury and dysfunction caused by nerve injury [15, 16]. Choi et al. reported epilepsy after neck pain in patients undergoing PELD, which was considered to be caused by increased intracranial pressure [17]. Bai et al. showed that it was appropriate to have a height of about 1 m between the flushing saline and the intervertebral foramen endoscopic inlet during the intervertebral foramen endoscopic operation, otherwise it was easy to cause spinal cord hypertension syndrome [18]. However, in clinical work, the author found that the low placement of intraoperative flushing fluid will lead to unclear vision in the operation area, while the placement height of flushing fluid for patients with spinal cord hypertension syndrome is mostly higher than 1 m, of which intervertebral approach is more common. This study is based on the correlation between the height of flushing fluid and the occurrence of spinal cord hypertension syndrome. Neuroelectrophysiological monitoring is often used in clinical diagnosis of intraoperative nerve injury monitoring [19]. Previous studies have shown that SEP+MEP+EMG monitoring is safe and effective in protecting spinal cord nerve function, and can provide reliable objective basis for accurately judging prognosis [20-23]. In this study, it was found that with the increase of flushing saline level, the alarm rate of neurophysiological detection increased significantly. Further research found that with the increase of hanging height of saline bag, the incidence rate of patients with spinal cord hypertension syndrome increased significantly, indicating

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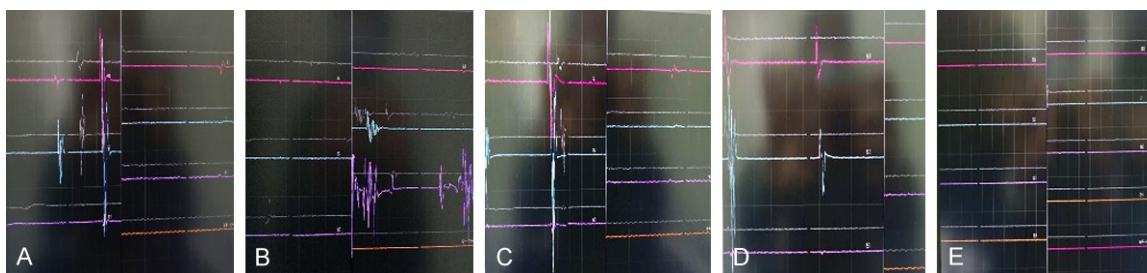


Figure 1. SEP+MEP+EMG monitoring status of patients during operation. A-C: The patient who has reached the alarm by monitoring abnormality; D: The patient who was monitored but has not reached the alarm; E: The patient who was monitored without abnormality. SEP: somatosensory evoked potential; EMG: electromyography; TcE MEP: transcranial electrical stimulation motor evoked potential.

Table 3. Comparison of incidence of post-operative spinal cord hypertension in four groups of patients (n, %)

Group	Incidence of postoperative spinal cord hypertension	
	Positive (n, %)	Negative (n, %)
Group A (n=25)	0 (0.00%)	25 (100.00%)
Group B (n=25)	0 (0.00%)	25 (100.00%)
Group C (n=25)	4 (16.00%)*.#	21 (84.00%)
Group D (n=25)	8 (32.00%)***.*###	17 (68.00%)
χ^2	16.667	
P	0.001	

Note: Compared with group A, *P<0.05, ***P<0.001; compared with group B, #P<0.05, ###P<0.001. Group A: the hanging height of saline bag at 60 cm; group B: the hanging height of saline bag at 70 cm; group C: the hanging height of saline bag at 80 cm; group D: the hanging height of saline bag at 90 cm.

that there is a certain correlation between hanging height of saline bag and the occurrence of spinal cord hypertension syndrome. A domestic study found that cerebrospinal fluid flow in the spinal canal was mainly concentrated in the front and rear directions, but less in the side [24]. During the operation, when a large amount of hanging height of saline bag was used for wash, the epidural pressure of the lumbar spine would increase, and after the pressure increased, the cerebrospinal fluid would flow to the side of the neck and head. As the channel is perpendicular to the lumbar back during the intervertebral surgery approach, the flushing saline is not easy to flow out of the surgery channel due to gravity factors, and therefore it will remain outside the dura. Yan et al. showed that when PELD was performed through the intervertebral approach, when patients had cervical pain, the epidural

Table 4. Comparison of ODI score of four groups of patients 3 months after operation ($\bar{x} \pm sd$)

Group	Comparison of ODI score
Group A (n=25)	10.34±3.12 [®]
Group B (n=25)	8.55±2.94*.*###,@@@
Group C (n=25)	11.35±3.45
Group D (n=25)	12.55±3.57
F	6.660
P	<0.001

Note: Compared with group A, *P<0.05; compared with group C, ###P<0.01; compared with group D, ®P<0.05, @@@P<0.001. Group A: the hanging height of saline bag at 60 cm; group B: the hanging height of saline bag at 70 cm; group C: the hanging height of saline bag at 80 cm; group D: the hanging height of saline bag at 90 cm. ODI: Oswestry disability index.

pressure in the cervical spinal canal elevated sharply [9]. The author believed that intraoperative flushing fluid accumulated in the epidural space in the cervical spinal canal, along with the thoracic and lumbar vertebrae. Moreover, the patient applied prone position during the operation and the cervical vertebra position was relatively low due to physiological curvature. Therefore, the high placement of the flushing fluid was related to the large water pressure, and the epidural pressure in the cervical spinal canal was more likely to increase sharply, which may lead to spinal venous reflux obstruction, transient ischemia and hypoxia of the spinal cord, and cause corresponding symptoms. In addition, during the operation, the dural sac may be ruptured and not found in time, resulting in flushing fluid entering the dural sac through the breach, causing the pressure in the dural sac to increase and inducing symptoms. In this study, it is shown that the height of flushing liquid is about 70 cm.

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Table 5. Comparison of curative effect evaluation of Mac Nab in four groups of patients (n, %)

Group	Excellent	Good	Moderate	Poor	The excellent and good rate
Group A (n=25)	7 (28.00%)	7 (28.00%)	9 (36.00%)	2 (8.00%)	14 (56.00)
Group B (n=25)	12 (48.00%)	9 (36.00%)	3 (12.00%)	1 (4.00%)	21 (84.00%)*.#@@
Group C (n=25)	4 (16.00%)	9 (36.00%)	9 (36.00%)	3 (12.00%)	13 (52.00%)
Group D (n=25)	3 (12.00%)	7 (28.00%)	8 (32.00%)	7 (28.00%)	10 (40.00%)
χ^2	17.399				
P	0.043				

Note: Compared with group A, *P<0.05; compared with group C, #P<0.05; compared with group D, @@P<0.01. Group A: the hanging height of saline bag at 60 cm; group B: the hanging height of saline bag at 70 cm; group C: the hanging height of saline bag at 80 cm; group D: the hanging height of saline bag at 90 cm.

Further post-operative efficacy evaluation of the participants found that the ODI score and Mac Nab efficacy of the patients were better than those of the other three groups when the hanging height of saline bag was about 70 cm. Although there was no spinal cord hypertension syndrome compared with hanging height of saline bag at 60 cm, low placement of saline bag during the operation would lead to unclear vision in the operation area, thus affecting the operation effect and the postoperative recovery of the patients. For the group with hanging height of saline bag at 80 cm and 90 cm, the incidence of postoperative spinal cord hypertension syndrome increased, thus affecting the postoperative recovery of patients. Therefore, this study revealed that it was appropriate to set the hanging height of saline bag at about 70 cm.

We still needed to avoid or alleviate the occurrence of spinal cord hypertension in patients undergoing PELD via the intervertebral approach while strictly carrying out the operation [18, 25]. For this, we summed up the following points: (1) When symptoms of spinal cord hypertension were mild, the operating bed could be adjusted, with head high and feet low. In addition, the suspension height of flushing fluid could be reduced, and oxygen inhalation, warmth preservation, psychological comfort and other measures could be given. If the symptoms were still not relieved, the operation was immediately stopped, the flushing fluid was turned off, and the operate was applied after the symptoms were basically relieved; (2) When the working channel was about to enter the spinal canal, the operation should be completed as soon as possible to avoid prolonged perfusion and operation time and dural sac injury.

The sample size of this study is small, so it is necessary to further expand the sample size

for research. The observation time is short, so it is necessary to further increase the observation time to study the postoperative recovery of the two groups of patients.

To sum up, the occurrence of spinal cord hypertension when PELD was performed through the intervertebral approach under continuous epidural anesthesia was related to the placement height of intraoperative flushing fluid. The high placement of flushing fluid was related to the high occurrence of spinal cord-like hypertension. The hanging height of saline bag at about 70 cm is appropriate.

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Disclosure of conflict of interest

None.

Address correspondence to: Chunshan Luo, Department of Spinal Surgery, Orthopaedic Hospital of Guizhou Province, No.123 Shachong South Road, Nanming District, Guiyang 550007, Guizhou Province, China. Tel: +86-18302531583; E-mail: luochunshan6t3y@163.com

References

- [1] Sahoo MM, Mahapatra SK, Kaur S, Sarangi J and Mohapatra M. Significance of vertebral endplate failure in symptomatic lumbar disc herniation. *Global Spine J* 2017; 7: 230-238.
- [2] Meng Y, Wang X, Wang B, Wu T and Liu H. Aggravation and subsequent disappearance of cervical disc herniation after cervical open-door laminoplasty: a case report. *Medicine (Baltimore)* 2018; 97: e0068.
- [3] Rade M, Pesonen J, Kononen M, Marttila J, Shacklock M, Vanninen R, Kankaanpaa M and

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- Airaksinen O. Reduced spinal cord movement with the straight leg raise test in patients with lumbar intervertebral disc herniation. *Spine (Phila Pa 1976)* 2017; 42: 1117-1124.
- [4] Tulloch I and Papadopoulos MC. Giant central lumbar disc herniations: a case for the transdural approach. *Ann R Coll Surg Engl* 2018; 100: e53-e56.
- [5] Choi KC, Kim JS, Lee DC and Park CK. Percutaneous endoscopic lumbar discectomy: minimally invasive technique for multiple episodes of lumbar disc herniation. *BMC Musculoskelet Disord* 2017; 18: 329.
- [6] Hao Y, Liu T, Yu L, Ma C, Liu Y, Li Z and Zhang D. Percutaneous transforaminal endoscopic discectomy combined with Coflex interspinous process dynamic reconstruction system in treatment of youth lumbar disc herniation. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2017; 31: 191-196.
- [7] Liu YP, Gao LF, Xu YH, Hu JH, Wu GL and Hou XW. The clinical study of myeloid hypertension in the treatment of lumbar disc herniation by percutaneous transforaminal endoscopic lumbar discectomy. *Chin J Spine Spinal Cord* 2019; 4: 382-384.
- [8] Joh JY, Choi G, Kong BJ, Park HS, Lee SH and Chang SH. Comparative study of neck pain in relation to increase of cervical epidural pressure during percutaneous endoscopic lumbar discectomy. *Spine (Phila Pa 1976)* 2009; 34: 2033-2038.
- [9] Yan XL. Correlation between neck pain and changes of cervical epidural pressure during local anesthesia PELD operation. *Chongqing Yixue* 2016; 26: 3634-3637.
- [10] Brodke DS, Goz V, Voss MW, Lawrence BD, Spiker WR and Hung M. PROMIS PF CAT outperforms the ODI and SF-36 physical function domain in spine patients. *Spine (Phila Pa 1976)* 2017; 42: 921-929.
- [11] Macnab I. Negative disc exploration. An analysis of the causes of nerve-root involvement in sixty-eight patients. *J Bone Joint Surg Am* 1971; 53: 891-903.
- [12] Wang ZX and Hu YG. Factors associated with lumbar disc high-intensity zone (HIZ) on T2-weighted magnetic resonance image: a retrospective study of 3185 discs in 637 patients. *J Orthop Surg Res* 2018; 13: 307.
- [13] Lee JH and Lee SH. Physical examination, magnetic resonance image, and electrodiagnostic study in patients with lumbosacral disc herniation or spinal stenosis. *J Rehabil Med* 2012; 44: 845-850.
- [14] Azimi P and Benzel EC. The low-back outcome scale and the Oswestry disability index: are they reflective of patient satisfaction after discectomy? A cross sectional study. *J Spine Surg* 2017; 3: 554-560.
- [15] Mahesha K. Percutaneous endoscopic lumbar discectomy: results of first 100 cases. *Indian J Orthop* 2017; 51: 36-42.
- [16] Kuonsongtum V, Paiboonsirijit S, Kesornsak W, Chaiyosboorana V, Rukskul P, Chumnanvej S and Ruetten S. Result of full endoscopic uniportal lumbar discectomy: preliminary report. *J Med Assoc Thai* 2009; 92: 776-780.
- [17] Choi G, Kang HY, Modi HN, Prada N, Nicolau RJ, Joh JY, Pan WJ and Lee SH. Risk of developing seizure after percutaneous endoscopic lumbar discectomy. *J Spinal Disord Tech* 2011; 24: 83-92.
- [18] Bai YB. Beis technical operation specification for intervertebral foramen. In: Bai YB, editor. Beijing: People's Medical Publishing House; 2015. pp. 54.
- [19] Zhong W, Wang J, Zhang W, Liu P, Visocchi M and Li ST. Combination of magnetic resonance imaging and electrophysiological studies in lumbar disc herniation. *Acta Neurochir Suppl* 2017; 124: 271-275.
- [20] Acharya S, Palukuri N, Gupta P and Kohli M. Transcranial motor evoked potentials during spinal deformity corrections-safety, efficacy, limitations, and the role of a checklist. *Front Surg* 2017; 4: 8.
- [21] Thirumala PD, Crammond DJ, Loke YK, Cheng HL, Huang J and Balzer JR. Diagnostic accuracy of motor evoked potentials to detect neurological deficit during idiopathic scoliosis correction: a systematic review. *J Neurosurg Spine* 2017; 26: 374-383.
- [22] Kobayashi K, Imagama S, Ito Z, Ando K, Hida T, Ito K, Tsushima M, Ishikawa Y, Matsumoto A, Nishida Y and Ishiguro N. Transcranial motor evoked potential waveform changes in corrective fusion for adolescent idiopathic scoliosis. *J Neurosurg Pediatr* 2017; 19: 108-115.
- [23] Tobert DG, Glotzbecker MP, Hresko MT, Karlin LI, Proctor MR, Emans JB, Miller PE and Hedequist DJ. Efficacy of intraoperative neurophysiologic monitoring for pediatric cervical spine surgery. *Spine (Phila Pa 1976)* 2017; 42: 974-978.
- [24] Yao WW, Chen XR, Shen TZ and Yang SX. MRI study for the flow of cerebrospinal fluid in normal volunteers. *Chin Computed Med Imag* 2001; 7: 289-294.
- [25] Bai YB, Li SP, Wang LW, Jian W, Xie MJ and Bai RT. The modified TESSYS technique for the treatment of lumbar nerve root canal stenosis. *J Cervicodynia Lumbodynia* 2015; 36: 16-19.