

Soleus muscle H-reflex monitoring in endoscopic surgery under general anesthesia percutaneous interlaminar approach

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Abstract. The clinical value of soleus muscle H-reflex monitoring in general anesthesia percutaneous interlaminar approach was investigated. A total of 80 cases with unilateral L5-S1 disc herniation between January 2015 and October 2016 were randomly divided into control group (without soleus muscle H-reflex monitoring, n=40) and observation group (with soleus muscle H-reflex monitoring, n=40). Results showed that the operation time of the observation group was shorter than that of the control group ($P<0.05$), and the blood loss during the operation was less than that of the control group ($P<0.05$). The length of postoperative hospital stay was shorter than that of the control group ($P<0.05$). At 24 h after operation, the amplitude of H-reflex in diseased side soleus muscle was significantly lower than that in healthy side ($P<0.05$). The preoperative, postoperative and 24 h postoperatively, the latency of H-reflex in diseased side soleus muscle was shorter than that of healthy side ($P<0.05$). The latency and amplitude of H-reflex latency in soleus muscle were significantly lower ($P<0.05$), and the height of intervertebral space in observation group was significantly higher than that in control group ($P<0.05$). The total percentage of postsurgical sensory dysfunction, dyskinesia, post-root canal stenosis, disc herniation and cerebrospinal fluid leakage was lower than that of the control group ($P<0.05$). Japanese Orthopaedic Association score of the observation group was significantly higher at 1 month, and 1 year after operation lower than the control group ($P<0.05$). Taken together, soleus muscle H-reflex monitoring can effectively reduce the damage to the nerve roots under percutaneous endoscopic intervertebral endoscopic surgery under general anesthesia, improve the accuracy of surgery, reduce the complications, shorten the operation time and reduce the surgical bleeding, which is more beneficial to patients smooth recovery.

Introduction

The surgical treatment of intervertebral disc herniation is currently the most effective intervention method for patients with lumbar intervertebral disc herniation, but there is a certain proportion of nerve root injury or even spinal cord injury (1), thereby causing great negative impacts on patients (2). At present, there are many anesthesia methods in intervertebral disc surgery, such as local anesthesia, epidural anesthesia with motor function retained and general anesthesia (3). During surgery, the operation near the nerve root will lead to nerve tingling and other severe discomfort in patients, so how to effectively alleviate the patient's discomfort and improve the surgical safety are the research emphases at present (4).

There are many qualitative methods of non-invasive electrophysiological detection of nerve root or spinal cord injury, including H-reflex monitoring, F-wave detection and maximum H-wave amplitude measurement (5), among which the H-reflex monitoring of soleus muscle can effectively reflect the S1 nerve function (6) and can be used as the most effective monitoring index of surgery of lumbar intervertebral disc (7). In this study, therefore, the application value of H-reflex monitoring of soleus muscle in the endoscopic surgery via percutaneous interlaminar approach under general anesthesia was mainly investigated.

Patients and methods

General materials. A total of 80 patients with unilateral L5-S1 intervertebral disc herniation treated in Jinling Hospital (Nanjing, China) from January 2015 to October 2016 were selected, and they were all diagnosed via clinical manifestations, signs and imaging combined with electrophysiological examination. All patients enrolled were fully informed of the enrollment and voluntarily signed the informed consents, and this study was approved by the Medical Ethics Committee of Jinling Hospital (Nanjing, China). Before enrollment, patients had significant clinical symptoms and/or signs, radiating pain in the lower limb, numbness of limb, hypokinesia and decreased muscle function on the affected side; moreover, the magnetic resonance examination of lumbar vertebra showed that the patients suffered from lumbar intervertebral disc herniation complicated with nerve root compression on the affected side. Patients whose H-reflex of soleus muscle was

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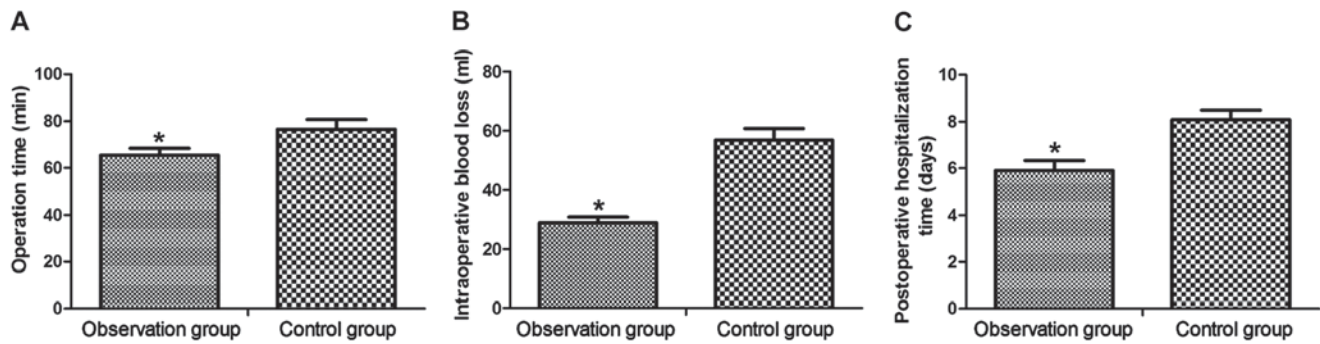


Figure 1. Comparisons of operation time, intraoperative blood loss and postoperative hospitalization time between two groups. (A) The operation time in observation group is shorter than that in control group ($P<0.05$); (B) the intraoperative blood loss amount in observation group is less than that in control group ($P<0.05$); and (C) the postoperative hospitalization time in observation group is shorter than that in control group ($P<0.05$).

not induced before enrollment, or those complicated with motor neuron disease, syringomyelia, benign or malignant spinal tumors, spinal deformity, fracture of lower limb, muscle atrophy of lower limb, multiple nerve disease, malnutrition, acute trauma, significant systemic inflammation, local infection, central nervous system disease, or who used to receive spinal surgery-related treatment were eliminated. Patients were divided into two groups with 40 cases in each group using the random number method. In observation group, there were 27 males and 13 females aged 25-60 years with an average of 43.5 ± 2.1 years; the course of disease was 3 months to 6 years with an average of 1.5 ± 0.2 years; in terms of occurrence site, there were 17 cases on the left, and 23 cases on the right. In control group, there were 26 males and 14 females aged 25-60 years with an average of 43.6 ± 2.1 years; the course of disease was 3 months to 6 years with an average of 1.6 ± 0.2 years; in terms of occurrence site, there were 16 cases on the left, and 24 cases on the right. There were no statistically significant differences in comparisons of sex, age, course of disease, or occurrence site, between the two groups ($P>0.05$).

Methods. Under general anesthesia, all patients underwent endoscopic intervertebral disc radiofrequency ablation via percutaneous translaminar approach using tracheal intubation. The operation in control group was mainly performed based on the clinical experience of surgeon, intraoperative identification should be strengthened, and surgical complications should be avoided. In observation group, H-reflex monitoring of soleus muscle was performed following the specific steps below: Nikon Kohden MEB 9400 (Nikon Corporation, Tokyo, Japan) electromyogram tester was used to detect the H-reflex of soleus muscle, in which the surface stimulating electrode was placed in the popliteal fossa and at 2 cm below medial and lateral heads of gastrocnemius muscle, and the reference control electrode was placed at 3 cm above the Achilles's tendon line. The stimulus wave width was adjusted into 1.0 ms, the filtering frequency was 10 Hz-10 kHz, and the initial current was set to 0.5 mA; during operation, the current stimulus intensity was gradually increased until the maximum-amplitude H-reflex appeared, with the single stimulus interval of 10 sec and the body surface temperature controlled at 34°C and above. Once H-reflex amplitude occurred or the latency time was decreased by more than 85%, surgical stimulus was withdrawn immediately, and the surgical operation was adjusted.

Observation indexes. The operation time, intraoperative blood loss and postoperative hospitalization time were compared between two groups. The amplitude and latency time of H-reflex of soleus muscle before and after operation in observation group were compared. Besides, the changes in relevant parameters to H-reflex of soleus muscle on the affected side in different operations during surgery were recorded, the changes in intervertebral space height before and after operation were compared between two groups, and related complications and changes in Japanese Orthopaedic Association (JOA) score were recorded.

The clinical efficacy on spinal cord function was scored using JOA scoring method, including four aspects (subjective feeling, clinical symptoms, daily activities and bladder function). The total score is 0-29 points; the lower the score is, the more obvious the functional disorder will be.

Statistical analysis. SPSS 13.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. Measurement data are presented as mean \pm standard deviation (mean \pm SD), t-test was used for the comparison of means between two groups, repeated measurement analysis of variance was used for the intragroup comparison of means at different observation time-points, and Chi-square test was used for the intergroup comparison of rates. $P<0.05$ was considered to indicate a statistically significant difference.

Results

Comparison of operation time, intraoperative blood loss and postoperative hospitalization time in the two groups. The operation time in observation group (65.5 ± 2.1 min) was shorter than that in control group (76.5 ± 3.2 min) ($t=18.176$, $P<0.05$); the intraoperative blood loss amount in observation group (28.9 ± 1.7 ml) was less than that in control group (56.8 ± 5.6 ml) ($t=30.151$, $P<0.05$); the postoperative hospitalization time in observation group (5.9 ± 1.1 days) was shorter than that in control group (8.1 ± 1.5 days) ($t=7.378$, $P<0.05$; Fig. 1).

Comparison of changes in H-reflex amplitude of soleus muscle before and after operation. Before operation, immediately after operation and at 24 h after operation, the H-reflex amplitude of soleus muscle on the affected side was significantly lower than that on the unaffected side ($P<0.05$; Table I).

Table I. Comparison of changes in H-reflex amplitude of soleus muscle before and after operation (mV, mean \pm SD).

Soleus muscle	Before operation	Immediately after operation	Twenty-four hours after operation
Unaffected side	3.59 \pm 0.15	3.60 \pm 0.15	3.61 \pm 0.14
Affected side	1.78 \pm 0.13	1.66 \pm 0.14	1.73 \pm 0.15
t-test	57.671	59.799	57.949
P-value	>0.05	>0.05	>0.05

Table II. Comparisons of latency time of H-reflex of soleus muscle before and after operation (ms, mean \pm SD).

Soleus muscle	Before operation	Immediately after operation	Twenty-four hours after operation
Unaffected side	27.8 \pm 0.29	25.3 \pm 0.21	28.6 \pm 0.30
Affected side	29.1 \pm 0.32	29.1 \pm 0.33	29.0 \pm 0.32
t-test	19.039	61.442	5.767
P-value	>0.05	>0.05	>0.05

Table III. Comparisons of intervertebral space height before and after operation between two groups (mm, mean \pm SD).

Groups	Before operation	One year after operation	t	P-value
Observation	8.15 \pm 0.15	8.13 \pm 0.10	0.702	0.485
Control	8.16 \pm 0.15	7.65 \pm 0.12	16.791	>0.05
t-test	0.298	19.435	-	-
P-value	0.766	>0.05	-	-

Comparison of latency time of H-reflex of soleus muscle before and after operation. Before operation, immediately after operation and at 24 h after operation, the latency time of H-reflex of soleus muscle on the affected side was significantly shorter than that on the unaffected side ($P<0.05$; Table II).

Changes in relevant parameters to H-reflex of soleus muscle on the affected side in different operations during surgery. In the nerve root exposure, nerve root stripping and nerve root displacement, the latency time of H-reflex of soleus muscle was: 26.3 \pm 0.23, 23.9 \pm 0.19, and 25.3 \pm 0.21 ms, respectively ($t=6.328$, $p=0.011<0.05$), and the H-reflex amplitude of soleus muscle was: 1.85 \pm 0.09, 1.33 \pm 0.02, and 1.83 \pm 0.08 mV, respectively ($t=5.206$, $p=0.021<0.05$). Among them, nerve root stripping had the greatest effects on the latency time and amplitude of H-reflex of soleus muscle (Fig. 2).

Comparison of intervertebral space height before and after operation between two groups. There was no statistically significant difference in the comparison of intervertebral

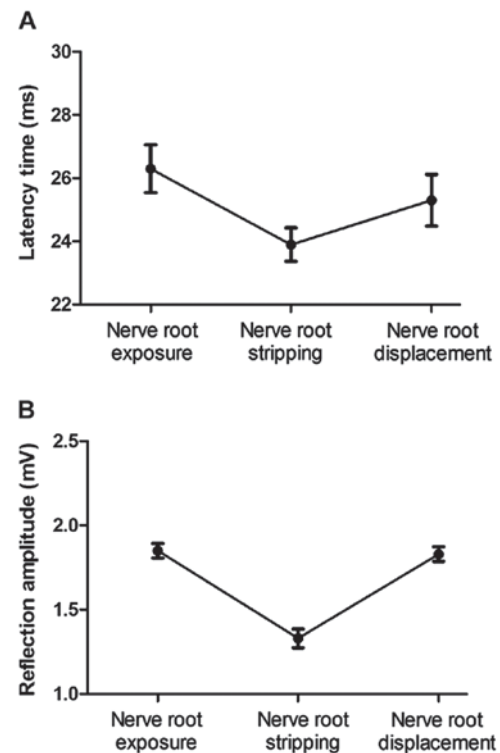


Figure 2. Changes in relevant parameters to H-reflex of soleus muscle on the affected side in different operations during surgery. (A) The latency time; and (B) amplitude of H-reflex of soleus muscle are significantly decreased in nerve root stripping ($P<0.05$).

space height between two groups before operation ($P>0.05$). The intervertebral space height in observation group at 1 year after operation was significantly higher than that in control group ($P<0.05$; Table III).

Comparisons of complications between two groups. Patients were followed-up for 1 year; results showed that the total proportion of postoperative sensory disturbance, dyskinesia, postoperative nerve root canal stenosis, recurrent herniation of intervertebral disc and cerebrospinal fluid leakage in observation group (12.5%) was significantly lower than that in control group (50.0%) ($\chi^2=13.091$, $P<0.05$) (Table IV).

Changes in JOA scores during treatment and follow-up between two groups. Before operation, and at 1 month and 1 year after operation, the JOA scores were: 13.2 \pm 0.9, 19.8 \pm 1.5, and 23.5 \pm 1.6 points, respectively, in observation group; and 13.3 \pm 0.9, 15.5 \pm 1.3, and 20.3 \pm 1.5 points, respectively, in control group. There was no statistically significant difference in the comparison of JOA score between two groups before operation ($F=0.497$, $p=0.621>0.05$); the JOA scores in observation group at 1 month and 1 year after operation were significantly lower than those in control group in the same periods ($F=13.701$ and 9.228, $P<0.05$; Fig. 3).

Discussion

Presently, lumbar intervertebral disc herniation is a clinically common disease that causes pain in the waist back and the lower limbs, and the open posterior discectomy is often needed

Table IV. Comparisons of related complications between two groups (n).

Groups	Sensory disturbance	Dyskinesia	Postoperative nerve root canal stenosis	Recurrent herniation of intervertebral disc	Cerebrospinal fluid leakage
Observation	1	1	1	2	0
Control	3	2	5	7	3

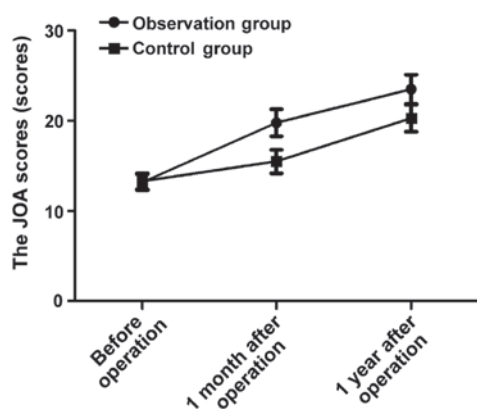


Figure 3. Changes in JOA scores during treatment and follow-up between two groups. The JOA scores in observation group at 1 month and 1 year after operation are significantly lower than those in control group in the same periods ($P < 0.05$). JOA, Japanese Orthopaedic Association.

in the surgical treatment of lumbar intervertebral disc herniation (8). In recent years, with the development of endoscopic technique, percutaneous transforaminal endoscopic technique has been increasingly widely used in clinical practice, which is characterized by small trauma, quick postoperative recovery, and few complications (9). Interlaminar approach effectively simplifies the operation and improves the safety of surgical treatment, but it may cause nerve root traction (10), leading to nerve root injury in patients. If the local anesthesia or intraspinal epidural anesthesia is used, the intraoperative pain and discomfort will be produced (11). In order to improve the comfort of patients, studies have reported that it is considered to adopt general anesthesia in surgical treatment (12). Under general anesthesia, however, surgeons cannot communicate with the patient in time during operation, failing to prevent the intraoperative nerve root injury, so the promotion of this surgical approach is affected (13). H-reflex of soleus muscle can effectively reflect the function of S1 nerve root, and it was used first to monitor the nerve function in spinal surgery in the 1990s, thereby reducing the nerve root injury and its complications (14).

In this study, all patients underwent surgical treatment under general anesthesia. H-reflex monitoring of soleus muscle was performed for patients in observation group. Compared with those in control group, the operation time in observation group was shorter, the intraoperative blood loss amount was less and the postoperative hospitalization time was shorter, suggesting that performing H-reflex monitoring of soleus muscle in endoscopic surgery via percutaneous interlaminar approach under general anesthesia can effectively shorten the operation time and hospitalization time, and reduce the intraoperative blood loss amount of patients. In addition,

the comparisons of amplitude and latency time of H-reflex of soleus muscle of patients in observation group before and after operation showed that the amplitude and latency time of H-reflex of soleus muscle on the affected side before operation, immediately after operation and at 24 h after operation were significantly lower and shorter than those on the unaffected side, indicating that the H-reflex monitoring of soleus muscle can effectively determine the nerve function, and determine the S1 nerve function more intuitively. At the same time, the research on the operations of nerve root during surgery showed that the amplitude and latency time of H-reflex of soleus muscle in nerve root stripping were significantly reduced, suggesting that nerve root stripping during surgery has the greatest effect on the nerve conduction function of nerve root, and attention should be paid to it during surgery, reducing the damage as far as possible. Moreover, the comparison of intervertebral space height between two groups before and after operation found that the intervertebral space height in observation group at 1 year after operation was obviously larger than that in control group, indicating that performing the H-reflex monitoring of soleus muscle in endoscopic surgery via percutaneous interlaminar approach under general anesthesia can improve the surgical effect more effectively, and reduce the loss of intervertebral space height after operation. Besides, patients were followed-up for 1 year, and the research on the complications showed that the total proportion of postoperative sensory disturbance, dyskinesia, postoperative nerve root canal stenosis, recurrent herniation of intervertebral disc and cerebrospinal fluid leakage in observation group (12.5%) was significantly lower than that in control group (50.0%), indicating that H-reflex monitoring of soleus muscle has positive significance in reducing the surgical complications. Finally, changes in JOA scores in both groups during treatment and follow-up revealed that the JOA scores in observation group at 1 month and 1 year after operation were significantly lower than those in control group in the same periods, further suggesting that performing the H-reflex monitoring of soleus muscle in endoscopic surgery via percutaneous interlaminar approach under general anesthesia is of great significance in improving the limb function after operation.

Previous studies have confirmed (15) that the latency time and amplitude of H-reflex of soleus muscle can be used as sensitive indexes of S1 nerve root injury, the former of which can reflect the nerve conduction function and speed (16); the change in amplitude can reflect the synchronous capacity of nerve fiber conduction (17). Operations of nerve root during surgery, such as nerve root exposure, nerve root stripping and nerve root displacement, may result in localized ischemia, followed by short-term and mild nerve demyelination (18). At this time, the latency time and amplitude of H-reflex of soleus

muscle changed more obviously. H-reflex monitoring of soleus muscle in observation group (19) can reflect the conditions of nerve root steadily and continuously, and the intraoperative nerve root injury will immediately lead to the change in relevant data, thus better guiding the surgeon to adjust the surgical operation in time and reducing complications (20).

In conclusion, H-reflex monitoring of soleus muscle can effectively reduce the nerve root injury caused by endoscopic surgery via percutaneous interlaminar approach under general anesthesia, improve the accuracy of surgery, reduce the complications, shorten the operation time, and reduce the intraoperative blood loss, thus benefiting the smooth rehabilitation of patients more.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Authors' contributions

HW designed the study, YG and LJ collected and analysed the data, WB and HW wrote the manuscript. WB and HW performed the follow-up. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Jinling Hospital (Nanjing, China). Signed written informed consents were obtained from the patients and/or guardians.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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