

Clinical treatment of lumbar disc herniation



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OBJECTIVE: To investigate the clinical effect of radiofrequency ozone and injection of anti-inflammatory analgesic solution into the internal orifice of nerve root combined with traditional Chinese medicine hook operation in the treatment of lumbar disc herniation.

METHODS: Patients with lumbar disc herniation who were admitted to our hospital on December 20, 2017 and June 19, 2019 were selected as the main research objects, and the included patients were divided into control group, basic group and comprehensive group by random number table method. Control group was treated with radiofrequency ozone therapy, basic group was treated with injection of anti-inflammatory analgesic solution into the internal orifice of nerve root in addition to the control group, comprehensive group was treated with traditional Chinese medicine hook operation in addition to the basic group. The clinical treatment effects were observed.

RESULTS: A total of 153 patients were included in this study, including 40 in the control group, 40 in the basic group, and 73 in the comprehensive group. The results showed that the NRS scores of control group were 3 ± 0.98 , 2 ± 0.93 and 2 ± 0.85 at 1 month, 3 months and 1 year after treatment, respectively. NRS scores in the basic group were 3 ± 0.18 , 2 ± 0.33 , and 2 ± 0.15 , respectively. NRS scores in the comprehensive group were 2 ± 0.78 , 1 ± 0.54 , and 1 ± 0.77 , respectively. Compared with the control group, there were significant differences in basic group and comprehensive group at each time point ($P < 0.05$). At the same time, compared with the basic group, the NRS score of the comprehensive group was statistically different ($P < 0.05$).

CONCLUSION: Radiofrequency ozone and injection of anti-inflammatory analgesic solution into the internal orifice of nerve root combined with hook operation can obtain good short-term and medium-term effects in the treatment of lumbar disc herniation. It is a safe and effective minimally invasive treatment method.

KEY WORDS: Internal orifice of nerve root, Lumbar disc herniation, Ozone

Introduction

Lumbar disc herniation is caused by lumbar disc degeneration, annulus fibrosus rupture, nucleus pulposus protrusion, stimulation and (or) compression of the spinal

nerve or spinal cord, resulting in low back and leg pain with root sciatica as the main symptom. It is a common clinical disease and frequently-occurring disease^{1,2}, traditional conservative treatment methods are generally not satisfactory and often require surgical fenestration treatment. No matter single segment or multi segment fenestration, the spinal biomechanical damage is inevitable, and long-term complications often occur^{3,4}. Minimally invasive interventional treatment avoids damage to the spine and preserves the mechanical stability of the spine and the balance of the biological environment⁵⁻⁷. For example, intervertebral disc radiofrequency thermocoagulation and traditional Chinese medicine

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hook operation. In radiofrequency thermocoagulation treatment, under the precise positioning of imaging and precise guidance of the navigation system, the electrode needle is introduced through the needle path, and the radiofrequency technology is used to output energy to act on the nucleus pulposus tissue, and directly denature, coagulate, contract and reduce the volume of nucleus pulposus in the diseased part of the herniated nucleus pulposus, and relieve the compression on nerve roots, and rarely damage the normal nucleus pulposus tissue, and at the same time repair the rupture of the annulus fibrosus, inactivated the newly-developed hypersensitive nerve terminals in the disc, and directly block the release of glycoprotein and β protein in the nucleus pulposus fluid. The warming effect has a good therapeutic effect on the injured annulus fibrosus, edema of nerve root and inflammatory reaction in spinal canal [8,9]. Traditional Chinese medicine hook operation and small curved needle is a kind of painless and minimally invasive closed treatment method of traditional Chinese medicine bone injury, which is between operation, non-operation and intervention, with large strength, small difficulty, small damage to patients, low cost, good effect and instant effect. In our department, the traditional Chinese medicine small curved needle is used for the hook operation, which can achieve the purpose of local decompression, tension reduction, release and dredging, so as to rejuvenate the local area, relax the tendons and activate the blood circulation, be active and flexible, and move freely.

At present, the clinical efficacy of minimally invasive interventional treatment of lumbar disc herniation is not clear. Therefore, this study focuses on patients with lumbar disc herniation as the main research object. It aims to explore radiofrequency ozone and injection of anti-inflammatory analgesic solution into the internal orifice of nerve root combined with Chinese medicine hook operation for treatment of lumbar disc herniation.

Materials and Methods

RESEARCH OBJECT

The patients with lumbar disc herniation in our hospital from December 20, 2017 to June 19, 2019 were

selected as the main research subjects, and the patients were numbered according to the order of their first visits, and the included patients were divided into control group, basic group and comprehensive group by random number table method. Control group was treated with radiofrequency ozone therapy, basic group was treated with injection of anti-inflammatory analgesic solution into the internal orifice of nerve root in addition to the control group, comprehensive group was treated with traditional Chinese medicine hook operation in addition to the basic group. The clinical treatment effects were observed. This study complies with the "Declaration of Helsinki of the World Medical Association" and has been approved by the ethics committee of our hospital. All patients signed an informed consent form.

DIAGNOSTIC CRITERIA

In this study, the diagnostic criteria of lumbar disc herniation refer to Hu Yougu's "Lumbar Disc Herniation"¹⁰. Based on the clinical history, physical signs and imaging examination, the diagnosis basis of lumbar disc herniation is as follows: 1. Leg pain is heavier than low back pain, and leg pain is typical pain in the sciatic nerve distribution area. 2. The skin in the nerve distribution area feels numb when being pressed. 3. The straight leg raising is reduced by 50% compared with the normal, and there may be positive results in good leg raising test. The bowstring test is performed by pressing the tibial nerve in the popliteal area to cause radiating pain at both ends of the limb. 4. Two of the four neurological signs appear (muscle atrophy, motor weakness, hypoesthesia and weakened reflexes). 5. Imaging findings are consistent with clinical examinations, which include spinal canal imaging, CT or MRI, etc.

INCLUSION CRITERIA

The inclusion criteria of this study include: 1. The degree of low back pain is greater than that of back pain; 2. The imaging examination shows that it is of protruding type; 3. Conservative treatment for more than 6 weeks without improvement; 4. Straight leg raising and strengthening test is positive; 5. The height of the

TABLE I - Clinical efficacy comparison (NRS score) of the three groups of patients

Group/NRS score	Cases	Before treatment	1 month after treatment	3 months after treatment	1 year after treatment
Control Group	n=40	5±2.65	3±0.98	2±0.93	2±0.85
Basic Group	n=40	5±1.88	3±0.18*	2±0.33*	2±0.15*
Comprehensive Group	n=73	5±1.68	2±0.78*#	1±0.54*#	1±0.77*#

*Compared with the control group, the difference was significant (P <0.05);

#Compared with the basic group, the difference was significant (P <0.05).

involved disc was greater than 75% of the adjacent disc height; 6. Age over 18 years old; 7. Patients who have signed an informed consent.

EXCLUSION CRITERIA

The exclusion criteria of this study include: 1. The height of the involved intervertebral disc is less than 25% of the adjacent disc height; 2. Complete destruction of the nucleus pulposus; 3. The imaging examination shows that it is of free prolapse type; 4. Spinal fracture, tumor, infection, coagulation disorders; 5. Spondylolisthesis above II°, spinal stenosis; 6. Patients with incomplete case data.

TREATMENT METHODS

The radiofrequency treatment operation method is as follows: the patient is in the prone position, the responsible disc intervertebral space is positioned under the C-arm, and after routine disinfection and draping, local anesthesia is performed in the responsible disc intervertebral space or 7-8 cm next to the intervertebral space, using radiofrequency puncture needle to puncture at this point. Confirm the position is correct after C-arm irradiation, the needle tip is located at the protrusion of the intervertebral disc, and a radiofrequency instrument is connected to give sensory stimulation and motor stimulation tests. The electrophysiological results confirm that the puncture needle is at the protrusion and far away from the nerve root. Radiofrequency ablation treatment is given three time: at 70 °C for 60 seconds, 80 °C for 60 seconds, and 90°C for 60 seconds. When heating, the patient feels soreness in the lumbosacral area and the affected limb. Intravertebral disc ozone therapy is given again, the injection concentration is 60mg/L ozone 10ml, the lumbosacral and affected limbs will also experience soreness during the ozone injection process, and the soreness disappears after the injection. In the basic group and the comprehensive group, withdraw the needle slowly and when the gas injection resistance of 5ml syringe disappears, the needle tip is confirmed to be located at the internal orifice of nerve root after C-arm irradiation. Inject 10ml of anti-inflammatory analgesic solution.

The patient has no symptoms of discomfort. Pull out the puncture needle, and then perform paravertebral 2.5-3.0 cm local anesthesia for the responsible disc and inject anti-inflammatory analgesic solution at the paravertebral, around the facet joints, and the external orifice of intervertebral foramen. Then the comprehensive group was treated with traditional Chinese medicine hook operation. The crochet needle expands the puncture needle eye and then pierces the hook to a depth of about 3.5-5.0 cm outward to the outer edge of the small joint

capsule of the responsible disc and the posterior branch of the spinal nerve root for loosening, and then insert the curved side of the small curved needle between the two intervertebral spaces, and press the protrusion of the intervertebral disc to the ventral and medial side, and release the outlet spinal nerve root at the posterior or lower edge of the upper vertebral body toward the cephalic side.

Finally, turn the bend of the needle outward and enter the lateral recess from the medial edge of the spinal facet joint capsule, the curved needle is drawn from the intervertebral foramen to loosen the adhesion of the spinal cord and the nerve root, and paste the dressing at the puncture site after finishing.

STATISTICAL ANALYSIS

In this study, SPSS 20.0 statistical software is used for data processing, and measurement data are expressed as mean \pm standard deviation ($\bar{x} \pm s$).

Count data is expressed in percentage (%). The comparison between the two groups that obey the normal distribution uses the t test; the comparison between the groups that does not obey the normal distribution uses the non-parametric test. Chi-square test is used for count data. $P < 0.05$ indicates that the difference is statistically significant.

Results

GENERAL INFORMATION

A total of 153 patients were enrolled in this study, including 73 in the comprehensive group, 22 males and 51 females; age 41-65 years old, average (53.32 \pm 11.46) years old; the shortest course of disease was 2 months and the longest 5.4 years, average (6.41 \pm 3.53) months. In the basic group, there were 40 cases, including 18 males and 22 females; age 43-69 years old, average (55.73 \pm 12.43) years old; the shortest course of disease was 4 months and the longest was 5 years, average (5.74 \pm 2.37) months. The control group consisted of 40 cases, 14 males and 26 females; age 44-68 years old, average (54.97 \pm 14.03) years old; the shortest course of disease was 4 months and the longest 5 years, average (6.74 \pm 3.37) months. There was no statistically significant difference in general conditions between the three groups of patients ($P > 0.05$), and they were comparable.

CLINICAL MANIFESTATIONS OF LUMBAR DISC HERNIATION IN THE THREE GROUPS

Among the 153 patients enrolled in this study, there are 31 cases of pure L4/5 intervertebral disc herniation, 21

cases of pure L5/S1 intervertebral disc herniation, 32 cases of two-segments (L3/4 and L4/5) protruding, 55 cases of two-segment (L4/5, L5/S1) protruding and 14 cases of three-segments (L3/4, L4/5, L5/S1) protruding. The symptoms and signs of the patients were consistent with the impact data, and they all had typical clinical manifestations of lumbar disc herniation, with varying degrees of low back pain and symptoms and signs of unilateral or bilateral lower extremity nerve damage.

COMPARISON OF CLINICAL EFFICACY BETWEEN THE THREE GROUPS OF PATIENTS

The follow-up period was 1-12 months after treatment, with an average of 7.5 months. The results showed no significant difference in NRS scores between the three groups before treatment, and the NRS scores of control group were 3 ± 0.98 , 2 ± 0.93 and 2 ± 0.85 at 1 month, 3 months and 1 year after treatment, respectively. NRS scores in the basic group were 3 ± 0.18 , 2 ± 0.33 , and 2 ± 0.15 , respectively. NRS scores in the comprehensive group were 2 ± 0.78 , 1 ± 0.54 , and 1 ± 0.77 , respectively. Compared with the control group, there were significant differences in basic group and comprehensive group at each time point ($P < 0.05$).

At the same time, compared with the basic group, the NRS score of the comprehensive group was statistically different ($P < 0.05$).

Discussion

Medical ozone is an allotrope of oxygen composed of three oxygen atoms. It is the most active form of oxygen¹¹. Ozone can decompose into oxygen and single oxygen atoms in about 20 minutes under normal temperature and pressure. A single oxygen has a strong activity, and has a strong oxidizing effect on bacteria, viruses and other microorganisms, as well as proteoglycans, lipids, and inflammatory mediators. Oxidized proteoglycan: It oxidizes nucleus pulposus proteoglycan, destroys nucleus pulposus cells, makes the osmotic pressure of the nucleus pulposus matrix unable to be maintained, and loses water, thereby reducing the pressure in the intervertebral disc, retracting the disc herniation, and eliminating the compression on the nerve root. Anti-inflammatory: Ozone can antagonize the immune factors and inflammatory mediators released in the inflammatory response, reduce nerve root edema and adhesion, and achieve the purpose of anti-inflammatory. Analgesia: The strong oxidation of ozone can quickly inactivate inflammatory mediators and eliminate pain. Loosen: Loosen the adhesion of nerve roots and intervertebral discs and surrounding tissues.

The anti-inflammatory analgesic solution is composed of 0.25% lidocaine needle, 4mg triamcinolone acetonide

injection, 0.9% sodium chloride solution. Lidocaine is a local anesthetic of the amide type. It has obvious excitatory and inhibitory bidirectional effects on the central nervous system, and there can be no pioneer excitement. When the blood concentration is low, analgesia and expansion of blood vessels can improve local blood circulation. Triamcinolone acetonide injection is an adrenal cortex hormone drug, which has anti-inflammatory and anti-allergic effects and suppresses immune response. This study found that injecting anti-inflammatory analgesic solution into the internal orifice of the nerve root can reduce nerve root edema and achieve the purpose of anti-inflammatory and analgesic.

Treatment of lumbar disc herniation should be more humane. In the treatment of lumbar disc herniation, more doctors prefer open surgery^{12,13}. Although our department does not deny that open surgery is intuitive and thorough in the treatment of lumbar disc herniation, we do not approve of it as a routine treatment, because this method is severely destructive in the normal biomechanics of the human body¹⁴⁻¹⁶, we have compressed the original indications for open surgery and recommend more patients to use minimally invasive treatment to maintain biomechanical stability. Practice has proved that minimally invasive treatment is effective in treating lumbar disc herniation and does not affect any subsequent treatment.

Indications and contraindications for minimally invasive treatment of lumbar intervertebral disc herniation^{17,18}: Absolute indications: a. Slow onset of the disease for no more than 1 year; b. Incomplete nerve injury; c. Patients accept minimally invasive treatment. Relative indications: a. Symptoms appear in slow-onset cases between 1 and 3 years with intermittent symptoms; b. It is accompanied by cardiovascular and cerebrovascular diseases at the same time; c. Patients have doubts about minimally invasive treatment. Contraindications: a. The disease persists for more than 3 years; b. Complete nerve damage; c. The prominent nucleus pulposus is completely free; d. Patient have severe cardiovascular and cerebrovascular diseases and mental diseases.

The key points of minimally invasive treatment of lumbar disc herniation: first of all, the diagnosis must be accurate. This requires clinicians engaged in minimally invasive treatment to have a solid theoretical foundation and sufficient clinical experience, especially the differential diagnosis should be accurate^{19,20}. Secondly, the positioning must be accurate. This requires doctors not only not to be sloppy in the diagnosis of nerve positioning, but also to be particularly accurate in positioning during the treatment process, otherwise the treatment effect will plummet²¹.

In addition, it is very important to provide psychological counseling for patients with lumbar disc herniation. Patients with lumbar disc herniation have a long onset period. Most patients will experience depression and even commit suicide. In the treatment of lumbar disc herni-

ation, patients must be encouraged and helped to build up the self-confidence to overcome the disease. With the advancement of science and technology and the continuous improvement of material and cultural living standards, our work and learning environment and living habits have changed, and the incidence of a series of spinal diseases such as cervical spondylosis and lumbar disc herniation has increased year by year. And the trend is that there are more young patients. Lumbar disc herniation is mainly manifested by pain in the lower back and legs, or not accompanied by pain and numbness in the lower limbs. Most patients have limited mobility and motor dysfunction, which brings great pain and inconvenience to the work and life of patients. Rapid pain relief and improvement of motor dysfunction have become the most urgent requirements of patients. We are constantly exploring clinically, consulting medical-related literature, going out to learn, summing up experience, and actively exploring new treatment methods. To sum up, through clinical application, we found that "clinical study on the treatment of lumbar disc herniation with radiofrequency ozone and injection of anti-inflammatory analgesic solution into the internal orifice of nerve root combined with hook operation of traditional Chinese medicine" has significant clinical effect compared with single lumbar disc radiofrequency treatment for lumbar disc herniation, which can quickly relieve pain symptoms, improve motor function, and directly treat the target of the lesion, that is the protrusion. It has been recognized and praised by the majority of patients, and has good social and economic benefits. In qualified hospitals, efforts should be made to relieve the pain of patients with lumbar disc herniation and resume normal life as soon as possible. This research still has the following shortcomings. First of all, although this study is a randomized controlled experiment, it is not blinded. Secondly, this study is a single-center clinical study, and a multi-center clinical study is still needed for further discussion. Finally, the sample size included in this study is relatively small, and it is still necessary to increase the sample size for further research.

Conclusion

Radiofrequency ozone and injection of anti-inflammatory analgesic solution into the internal orifice of nerve root combined with hook operation can obtain good short-term and medium-term effects in the treatment of lumbar disc herniation. It is a safe and effective minimally invasive treatment method.

Riassunto

OBIETTIVO DELLO STUDIO: Indagare l'effetto clinico dell'ozono a radiofrequenza e l'iniezione di una soluzione

analgesica antinfiammatoria nell'orifizio interno della radice nervosa combinata con l'agopuntura della medicina tradizionale cinese nel trattamento dell'ernia del disco lombare.

METODI: I pazienti con ernia del disco lombare che sono stati ricoverati nel nostro ospedale il 20 dicembre 2017 e il 19 giugno 2019 sono stati selezionati come principali oggetti di ricerca e i pazienti inclusi sono stati divisi in gruppo di controllo, gruppo di base e gruppo completo a random. Il gruppo di controllo è stato trattato con ozonoterapia a radiofrequenza, il gruppo di base è stato trattato con l'iniezione di una soluzione analgesica antinfiammatoria nell'orifizio interno della radice nervosa oltre al gruppo di controllo, il gruppo completo è stato trattato con l'agopuntura della medicina tradizionale cinese oltre a quella di base gruppo. Sono stati osservati gli effetti del trattamento clinico.

RISULTATI: In questo studio è stato incluso un totale di 153 pazienti, di cui 40 nel gruppo di controllo, 40 nel gruppo di base e 73 nel gruppo completo. I risultati hanno mostrato che i punteggi NRS del gruppo di controllo erano $3\pm 0,98$, $2\pm 0,93$ e $2\pm 0,85$ a 1 mese, 3 mesi e 1 anno dopo il trattamento, rispettivamente. I punteggi NRS nel gruppo base erano rispettivamente di $3\pm 0,18$, $2\pm 0,33$ e $2\pm 0,15$. I punteggi NRS nel gruppo completo erano rispettivamente di $2\pm 0,78$, $1\pm 0,54$ e $1\pm 0,77$. Rispetto al gruppo di controllo, c'erano differenze significative nel gruppo di base e nel gruppo completo in ogni momento ($P < 0,05$). Allo stesso tempo, rispetto al gruppo di base, il punteggio NRS del gruppo completo era statisticamente diverso ($P < 0,05$).

CONCLUSIONE: l'ozono a radiofrequenza e l'iniezione di soluzione analgesica antinfiammatoria nell'orifizio interno della radice nervosa combinata con l'agopuntura possono ottenere buoni effetti a breve e medio termine nel trattamento dell'ernia del disco lombare. È un metodo di trattamento minimamente invasivo sicuro ed efficace.

References

1. Ozcan S, Muz A, Altun AY, Onal SA: *Intradiscal ozone therapy for lumbar disc herniation*. Cellular and molecular biology (Noisy-le-Grand, France) 2018; 64(5):52.
2. Tang S, Mo Z, Zhang R: *Acupuncture for lumbar disc herniation: a systematic review and meta-analysis*. Acupuncture in Medicine, 2018; acupmed 2016, 011332.
3. Fjeld OR, Grøvre L, Helgeland J, et al.: *Complications, reoperations, readmissions, and length of hospital stay in 34 639 surgical cases of lumbar disc herniation*. The Bone & Joint Journal, 2019; 101-B(4):470-77.
4. Liu Y, Zhao JX, Tian YX: *Efficacy and safety of electroacupuncture in treatment of lumbar disc herniation: a protocol for a cohort study*. Journal of Traditional Chinese Medicine, 2019; 39(01):131-36.
5. Hao KN, Tang SY, Xie HN, Li XM, He XF: *Application of ozone therapy in interventional medicine*. Journal of Interventional Medicine, 2019; 2(1):8-11.

6. Chen WY, Wang K, Yuan WA, Zhan HS: *Relationship between lumbosacral multifidus muscle and lumbar disc herniation*. Zhongguo Gu Shang, 2016; 29(6):581-84.
7. Stagni S, Santis FD, Cirillo L, et al.: *A minimally invasive treatment for lumbar disc herniation: DiscoGel chemonucleolysis in patients unresponsive to chemonucleolysis with oxygen-ozone*. Interventional Neuroradiology, 2012; 18(1):97-104.
8. Zeng Z, Yan M, Dai Y, Qiu WD, Deng S, Gu XZ: *Percutaneous bipolar radiofrequency thermocoagulation for the treatment of lumbar disc herniation*. Journal of Clinical Neuroscience, 2016, 39-43.
9. Ankur J, Goyal GN: *Comparative study of intradiscal oxygen-ozone therapy, electrothermal therapy, and their combined effects for the treatment of lumbar disc herniation*. Spine J 2010; 10(9): S70-S71.
10. Hu YG: *Lumbar disc herniation*, 2nd Ed. Beijing: People's Medical Publishing House. 1995.2.21.
11. Wei CJ, Li YH, Chen Y, et al.: *Percutaneous intradiscal oxygen-ozone injection for lumbar disc herniation: No need of perioperative antibiotic prophylaxis*. Nan Fang Yi Ke Da Xue Xue Bao, 2007; 27(3):384-86.
12. Paulsen RT, Carreon L Y, Andersen M: *Patient-reported outcomes after surgery for lumbar disc herniation, a randomized controlled trial comparing the effects of referral to municipal physical rehabilitation versus no referral*. Spine, 2020; 45.
13. Ricarda L, David P, Krismer M, Haid C, Obwegeser A, Thaler M: *Braking reaction time before and after surgery for patients with recurrent lumbar disc herniation*. Journal of neurosurgery, Spine, 2019; 1-5.
14. Andersen SB, Birkelund R, Andersen M, Carreon L Y, Coulter A, Steffensen KD: *Factors affecting patient decision-making on surgery for lumbar disc herniation*. Spine, 2018; 44(2):1.
15. Kim CH: *Surgical timing in lumbar disc herniation surgery*. Neurospine, 2020; 17(1):213-14.
16. Postacchini F: *Lumbar disc herniation: A new equilibrium is needed between nonoperative and operative treatment*. Spine, 2001; 26(6):601.
17. Li SH, Zhou MW, Li YJ, Liang XY: *Update of research on minimally invasive treatment of lumbar disc herniation*. China Journal of Orthopaedics & Traumatology, 2012; 25(4):348-52.
18. Wu ZQ, Wei LX, Li J, et al.: *Percutaneous treatment of non-contained lumbar disc herniation by injection of oxygen-ozone combined with collagenase*. European Journal of Radiology, 2009; 72(3):499-504.
19. Alvi MA, Kerezoudis P, Goncalves S, Goyal A, Bydon M: *Operative approaches for lumbar disc herniation: A systematic review and multiple treatment meta-analysis of conventional and minimally invasive surgeries*. World Neurosurgery, 2018; 17(10):S266.
20. Salame K, Lidar Z: *Minimally invasive approach to far lateral lumbar disc herniation: Technique and clinical results*. Acta Neurochirurgica, 2010; 152(4):663-68.
21. Yeung AT, Yeung CA: *Minimally invasive techniques for the management of lumbar disc herniation*. Orthopedic Clinics of North America, 2007; 38(3):363-72.