Clinical Study of Hydraulic Perfusion Pump and Traditional Water Jet Irrigation for Percutaneous Endoscopic Lumbar Discectomy

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Research article

Keywords: Hydraulic perfusion pump, Traditional water jet irrigation, Percutaneous endoscopic lumbar discectomy

Posted Date: January 13th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-141483/v1

Abstract

Objective: To compare clinical outcomes of hydraulic perfusion pump and traditional water jet irrigation in percutaneous endoscopic lumbar discectomy by a prospective randomized controlled study.

Methods: From January 2016 to December 2018, 72 patients with lumbar disc herniation and failed conservative treatment were enrolled in this study. According to the odd number of the last digit of the hospitalization number, the patients were randomly divided into a hydraulic perfusion pump group and a traditional water jet irrigation group, 36 cases in each group. There were no significant differences in gender, age, prominent segment, clinical classification, preoperative pain visual analog scale (VAS), and Japanese Orthopedic Association (JOA) scores between two groups (P>0.05). The same surgeon performed all operations. These operations were performed by hydraulic perfusion pump flushing and traditional water flushing assisted surgery. The patients were followed up for 12 to 24 months (mean 15.7 months). The operation time, blood loss, hospital time, visual analog scale (VAS) for follow-up pain after one day and two weeks, and the last follow-up JOA scores. The type and incidence of postoperative complications were compared between two groups.

Results: Compared with the traditional water flushing group, the operation time of the hydraulic perfusion pump group was short [(65.5±21.3) min vs. (74.8±19.9) min, t=9.465, P=0.003]. Blood loss was less [(21.2±12.9) ml vs. (27.4±14.1) ml, t=8.331, P=0.012]; there was no statistical difference in hospitalization time. The pain visual analog scale (VAS) and the last follow-up JOA scores in one day, two weeks were better than preoperative, but there was no statistical difference between the groups (P>0.05). In the traditional water flushing group, the symptoms of increased intracranial pressure like headache and neck pain occurred during the operation, which was forced to shorten the operation time in 5 cases, nerve root adventitia injury in 4 cases, and postoperative recurrence in 4 cases. In the hydraulic perfusion pump group, no patient had the symptoms of increased intracranial pressure like headache and neck pain, and nerve root adventitia injury in 1 case and 2 cases of postoperative recurrence. The incidence of complications in the hydraulic perfusion group was lower than that in the traditional water flow group.

Conclusion Hydraulic perfusion pump and traditional water-flow irrigation assisted percutaneous endoscopic lumbar disc herniation can achieve satisfactory clinical results. However, the former has short operation time, clear vision in operation, less bleeding, and less in-operation and postoperative complications.

Introduction

With the development of minimally invasive surgical techniques, percutaneous trans foramina endoscopic discectomy has been highly praised by more and more scholars due to its small trauma, fast recovery, and low cost [1–6]. The traditional water flushing method is to hang the normal saline to a certain height, maintain the intraoperative water pressure through the height difference, reduce the intraoperative bleeding, and maintain the clear surgical field of vision. However, with the decrease of

water flow, the traditional water flushing method cannot maintain the continuous and stable water pressure. To get a clearer vision, most surgeons are used to hanging the normal saline to a higher position, so the intraoperative pressure on the spinal cord is higher, and the complications of increased intracranial pressure are more likely to occur. We compared the clinical effect of hydraulic perfusion pump and traditional water flushing in percutaneous trans foramina lumbar discectomy through randomized controlled study to provide a basis for a better selection of auxiliary technology percutaneous trans foramina endoscopic lumbar discectomy.

1. Materials And Methods

1.1 Baseline Data

Inclusion criteria: ① unilateral lumbar and legs pain; ② weakening of muscle strength, sensation and reflex of the corresponding part of the compression segment innervation area, and positive results of straight leg elevation test and strengthening test; ③ Magnetic Resonance Imaging (MRI) and Computer Tomography (CT) findings were consistent with the symptoms and signs of the patients, and there was no spinal stenosis and lumbar instability at the same segment; ④ three months regular conservative treatment was ineffective.

Exclusion criteria: ① recurrent lumbar disc herniation; ② multilevel lumbar disc herniation; ③ combined with lumbar spinal stenosis or lumbar instability; ④ patients with other diseases unable to tolerate the surgery [7].

From January 2016 to December 2018, 72 patients were randomly divided into the hydraulic perfusion pump group and the traditional water flushing group, with 36 cases in each group. All patients were operated on by the same authors. The two groups' general data are shown in Table 1, and there is no significant statistical difference. Our hospital’s ethics committee has approved this study. All the patients agreed and signed the informed consent—the ethical approval number: 2015-KY-019.

Table 1 Comparison of two groups of general data（n=36）

Group	Age	Gender		Prominent type				Operative segment		
		male	female	A	B	C	D	$L_{3/4}$	$L_{4/5}$	L_5/S_1
Hydraulic perfusion pump	**45.7±12.7**	2l	16	13	12	7	4	5	19	12
Traditional Water jet irrigation	**46.2±10.3**	22	14	11	15	8	2	3	20	13
t(x^2)	t=2.431	x^2=0.229		x^2=1.233				x^2=0.566		
P	0.143	0.633		0.745				0.754		

*A-central type; B-lateral type; C-Extreme lateral type; D-free type

1.2 Operation Methods

All patients were in the prone position, and 1% lidocaine local anesthesia was performed with a downward lateral path foramina endoscopic discectomy. In the hydraulic perfusion pump group, using hydraulic perfusion pump for continuous water flow flushing. The water pressure was maintained at 60-80mm H_2O, and the water flow rate was maintained at 80-100ml/min. According to the patient's blood pressure, age, and other conditions, personalized setting the water pressure and flow rate, starting from the lowest value, the water pressure and flow rate were appropriately increased according to the intraoperative visual field. In the traditional water flushing group, the normal saline was suspended on the hook 1m higher than the patient. The suspension height was increased appropriately according to the operation's visual field, up to 1.5m. The water pressure was maintained at 74-110 mm H_2O. The flow rate was maintained at 120-150 ml/min.

1.3 Observation Index and Curative Effect Evaluation

The operation time, intraoperative blood loss, postoperative hospital stays, and complications were recorded. The amount of bleeding during the operation is calculated by the following method: the mixed liquid of flushing water and blood during the operation is sucked into a graduated suction bottle, which can be accurate to 10 ml, and the liquid above the scale is pumped into the measuring cup, which can be accurate to 0.1ml, calculating the total amount of fluid, and then subtract the remaining saline to get the intraoperative blood loss, VAS score, JOA score, and MRI were performed on the first day and two weeks and the last follow-up after operation. The preoperative scoring and physical examination and scoring on the first day after the operation was completed by author 2, who made an appointment with those patients by phone two weeks after the operation. Then, those patients go to the author's clinic for physical examination scoring. All physical examination and scoring were completed by the author 2.

Observation index: □ operation time, intraoperative blood loss, length of hospital stay; □ VAS score at one day, two weeks and the last follow-up after operation; □ JOA score at the last follow-up; □ intraoperative and postoperative complications were recorded, including spinal cord hypertension, nerve root adventitia injury, postoperative recurrence, etc.

1.4 Statistical Analysis

SPSS 19.0 (Statistical Product and Service Solutions) statistical software was used. The measurement data were expressed by`X ± s. The VAS and JOA scores were compared by paired t-test before and after the operation. The independent-sample t-test was used to compare the measurement data between the two groups. The chi-square test was used to compare the count data between two groups. The difference was statistically significant ($P < 0.05$).

2. Results

See tables 2 and 3. The operation was completed in both groups. All patients were followed up for 12-24 months (average 15.7 months). Compared with the traditional water washing group, the operation time of the hydraulic perfusion pump group was shorter [(65.5 ± 21.3) min vs (74.8 ± 19.9) min, t = 9.465, P = 0.003], and less intraoperative bleeding [(21.2 ± 12.9) ml vs (27.4 ± 14.1) ml, t = 8. 331, P = 0. 012]. There was no significant difference in the length of hospital stay. The VAS and JOA scores at one day, two weeks, and the last follow-up were improved in both groups, but there was no significant difference between them (P > 0.05).However there were 5 cases of symptoms of increased intracranial pressure like headache and neck pain, 4 cases of nerve root adventitia injury, and 4 cases of postoperative recurrence in the traditional water irrigation group. There was no increased intracranial pressure of symptoms of headache and neck pain in the hydraulic perfusion pump group, 1 case of nerve root adventitia injury, and 2 cases of postoperative recurrence. The incidence of complications in the hydraulic perfusion group was lower than that in the traditional water jet irrigation group. The recurrence patients in both groups received minimally invasive surgery again and recovered well after the operation.

Table 2 Comparison of two groups of observation indexes **($\bar{x}$±s, n=36)**

Group	Operation Time(min)	Intraoperative Bleeding(ml)	Length of Hospital Stay(d)	Complications (cases)
hydraulic perfusion pump group	65.5±21.3	21.2±12.9	5.0±1.0	3
traditional water jet irrigation group	74.8±19.9	27.4±14.1	6.0±2.0	13
t(x^2、Z)	t=9.465	t=8.331	t=3.412	x^2=8.036
P	0.003	0.012	0.221	0.005

Table 3 Comparison of VAS and JOA scores **($\bar{x}$±s, n=36)**

	Group	Preoperative	1 week	2 week	last follow-up
VAS	**Hydraulic perfusion pump group**	5.8±2.3	2.2±0.9	1.6±0.5	0.4±0.1
	traditional water jet irrigation group	5.9±1.9	2.4±1.3	1.5±0.6	0.5±0.2
	t、p	-1.869,0.071	-0.284,0.742	7.532,0.075	3.563,0.221
JOA	**hydraulic perfusion pump group**	8.7±6.9	—	—	26.9±2.8
	traditional water jet irrigation group	8.9±7.1	—	—	26.2±3.1
	t、p	-0.342,0.693	—	—	2.935,0.091

3. Discussion

Lumbar disc herniation is a common disease, and the life and work of severe patients are affected, and some cases need surgical treatment [8]. The conventional small incision discectomy is the gold standard for the treatment of this disease. The intervertebral foramen is exposed through the small posterior incision, and the nerve roots and protruding nucleus pulposus are removed, and the nucleus pulposus tissue is removed under direct vision. This operation requires high visual acuity of the operator, and the surgical field is small. Most of the nucleus pulposus is removed during the operation. Long-term follow-up shows intervertebral space stenosis and bone hyperplasia at the vertebral body's edge can quickly occur at the diseased segment after operation [9-11].

The development of endoscopy technology provides us with a new choice. The minimally invasive technique of transformational endoscopy has become the first choice to treat lumbar disc herniation. This technology has many advantages, such as small trauma, short recovery time, less pain, low cost, and highly praised by experts and professors [12-13]. Of course, there may be intraoperative hemorrhage, intraoperative intracranial pressure increase, nerve root injury, the dural sac injury, postoperative infection, postoperative hematoma formation, postoperative recurrence, and other complications [14-20]. The intraoperative bleeding is usually stopped by bipolar electrosurgical unit, increasing normal saline pressure, and pressing the working cannula. If there is severe bleeding, the operation should be suspended, and the gelatin sponge should stop bleeding. At present, the author usually uses the above three methods together. Improving the pressure of normal saline is the premise of keeping the operation vision clear, which provides the possibility of finding the bleeding point and using bipolar electrosurgical unit or working cannula to compress hemostasis.

Whether it is lateral or posterior laminectomy, endoscopic minimally invasive surgery needs flowing normal saline to maintain the visual field's pressure, reduce intraoperative bleeding, and keep the visual field clear. The standard method is to hang normal saline to a certain height to maintain water pressure. Too low water pressure cannot thoroughly wash out the blood in the operation field, cannot prevent the capillary blood leakage in the operation field, the operation vision is blurred, the operation difficulty is increased, and the operation time is the intraoperative and postoperative complications are increased. High water pressure can keep the vision of the operation clear. However, the pressure on the dural sac is increased, which may cause the symptoms of intracranial pressure increased during operation, such as neck pain, headache, dizziness, even nausea, and vomiting. Some patients need to suspend the operation and finish the operation as soon as possible after reducing the water pressure. Because the increase of intracranial pressure greatly influences patients, and it is impossible to measure the intracranial pressure during the operation accurately, five patients in the traditional water washing group had neck pain. The operator lowered the suspension height of normal saline, raised the head, suspended the operation, and operated again after the neck pain disappeared. The saline pressure is the most critical parameter, so try to control the minimum water flow speed to reduce saline consumption.

This study's key topic is to maintain a balance between the pressure and the water flow velocity, which can ensure the clear vision of surgery, reduce the consumption of normal saline, and reduce the occurrence of intraoperative and postoperative complications. The surgeon also found that the method could not maintain constant water pressure entirely and could not accurately adjust the flow rate. The reason is that normal saline is continuously decreasing. The liquid level is continually falling, and the relative height between the liquid and surgical fields is continuously decreasing. It is impossible to keep raising the physiological saline's height to maintain the water pressure during the operation. Therefore, most surgeons will try to hang the normal saline as high as possible to maintain a clear vision and reduce the operation time.

The author got a hint from the use of the hydraulic perfusion pump in urinary surgery in the cystoscope [21] and used the hydraulic perfusion pump to pump the normal saline into the surgical field of vision. The hydraulic perfusion pump consists of a perfusion pump and a perfusion rubber strip. The perfusion pump applies preset pressure and fluid velocity to the perfusion rubber strip to maintain constant water pressure and water flow velocity in the surgical field. One end of the perfusion rubber strip is connected with the saline bag, and the other end is connected with the inlet of the intervertebral foramen mirror. Under the continuous pressure of the perfusion pump, the normal saline with constant water pressure and water flow speed is provided for the surgical field. According to the normal saline hanging 1-1.5m from the patient's height, the author calculated that the effluent pressure was maintained at 74-110 mmHg, and the preliminary experiment was carried out. It was concluded that the scheme of maintaining the perfusion pressure at 60-80 mmHg and the water flow velocity at 80-100ml /min could maintain the clear vision of surgery and reduce the consumption of physiologic saline. During the operation, the water pressure and flow rate were set according to the patient's blood pressure and age. The water pressure and flow rate were appropriately increased according to the intraoperative visual field, starting from the lowest value. The conventional water pressure was maintained at 60-80 mmHg, and the water flow velocity was maintained at 80-100ml /min. In this study, there was no significant difference between the two groups. However, the operation time and intraoperative bleeding in the hydraulic perfusion pump group were significantly lower than those in the traditional water washing group. In the hydraulic perfusion pump group, there was no case occurring the symptoms of increased intracranial pressure, 1 case of nerve root adventitia injury, and 2 cases of postoperative recurrence. In the traditional water washing group, increased intracranial pressure symptoms caused operation time shortened in 5 cases. The adventitia of nerve root was damaged in 4 cases, and recurrence occurred in 4 cases. The incidence of intraoperative and postoperative complications in the hydraulic perfusion group was significantly lower than that in the traditional water flushing group.

To sum up the reasons, the hydraulic perfusion pump can accurately calculate the water pressure and water flow velocity when it is used in the intervertebral foramen endoscopic surgery. When it is used, it can start from the lower water pressure and water flow speed. According to the intraoperative visual field, the water pressure and flow velocity should be appropriately increased according to the intraoperative visual field situation. The pressure on the spinal dural sac caused by water pressure should be reduced as

far as possible under maintaining a clear vision. The constant water pressure and water flow velocity should be maintained.

Reduce the effect of more considerable water pressure fluctuation on the spinal cord and reduce increased intracranial pressure symptoms. Constant water pressure and water flow velocity can better flush out the bleeding during the operation. The water pressure slightly higher than the capillary pressure is used to compress the ruptured capillaries. Without increasing the pressure of the spinal cord's dural sac, it can prevent capillary hemorrhage, keep the visual field clear, and reduce the operation time. When the nerve roots were decompressed, the direction of the nerve roots could be observed more clearly. The nucleus pulposus and other pressing materials could be removed, the probability of damage to the nerve root outer membrane would be reduced, the residual of the pressure substances could be reduced, and the postoperative recurrence could be reduced. The initial perfusion pressure should be appropriately increased in patients with hypertension before an operation, which may be associated with higher capillary pressure in the spinal canal of patients with hypertension. Elderly patients have immense vascular fragility, low spinal cord dural sac tolerance, intervertebral foramen stenosis, and superior adhesion. If the operation time is extended, the initial perfusion pressure should be reduced appropriately; the flow velocity should be increased appropriately, the spinal cord dural sac should be reduced.

Furthermore, the blood flow can be washed to remove the bleeding and keep the vision clear. After adequate decompression, the pressure and water flow velocity can be adjusted appropriately in a short time when the lateral recess is finally explored. Due to the abundant blood supply

of the lateral recess and the difficulty of hemostasis with bipolar electrosurgical unit during the operation, it is better to find the bleeding point of lateral recess and altogether stop bleeding by a short-term increase of water pressure and water flow velocity.

The limitations of this study are as follows:

 the perfusion pressure is maintained at 60-80 mmHg, and the water flow velocity is maintained at 80-100ml / min, and the initial water pressure and water flow velocity are estimated according to the patient's age, blood pressure, and other conditions, which is not accurate. Future clinical research should also consider other influencing factors, such as diabetes, rheumatoid arthritis, and other complications, through the development of a more accurate scoring table to set Initial data;

 There was no accurate instrument to measure intracranial pressure during the operation, and the data was not accurate enough to diagnose the increased intracranial pressure by the patients with neck pain;

 The number of included samples is relatively small, and it is necessary to increase the number of cases in the future.

4. Conclusion

Many experts have respected intervertebral foramen minimally invasive surgery, and its application range is more and more extensive. With the in-depth study of this operation and the development of minimally invasive instruments, the indications have been continuously expanded. Lumbar spinal stenosis, lumbar spondylolisthesis, even thoracic spinal stenosis, and degenerative scoliosis are also widely used [22-24]. How to better assist transforaminal endoscopic surgery is our next research direction. Hydraulic perfusion pump is a conventional instrument in significant hospitals, widely used in laparoscopic surgery by gynecology and urology. The hydraulic perfusion pump can accurately calculate the water pressure and water flow speed, and minimize the pressure of the water pressure on the spinal dural sac while maintaining a clear vision, maintain constant water pressure, and reduce the occurrence of symptoms of increased intracranial pressure, lower the water flow speed can reduce the consumption of normal saline, and there are fewer intraoperative and postoperative complications. The instrument can also better assist us in completing the intervertebral foramen mirror's minimally invasive surgery, which is worthy of our promotion.

Typical cases

The patient, male, 32years old, was admitted to the hospital with left lumbar and legs pain for four months ,and was diagnosed with No.4 and 5 lumbar disc herniation, VAS score of 9 points, JOA score of 8 points, no other complications. Under local anesthesia, perform lateral transforaminal endoscopic nucleus pulposus excision, the operation time was 47 minutes, the intraoperative blood loss was 11.2ml, there was no epineurium injury, no residual nucleus pulposus, and no intracranial pressure increase. The hospital stay was 4 days. The VAS score was 1 point at 1 and 2 weeks after the operation, the VAS score was 0 at the last follow-up, and the JOA score was 28 points. There is no recurrence after 3 years.

Abbreviations

Visual Analog Scale (VAS)

Japanese Orthopedic Association (JOA)

Magnetic Resonance Imaging (MRI)

Computer Tomography (CT)

Statistical Product and Service Solutions (SPSS)

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