Prospective Study

Comparison of 3 Anesthetic Methods for Percutaneous Transforaminal Endoscopic Discectomy: A Prospective Study

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Background: Percutaneous transforaminal endoscopic discectomy (PTED) under local anesthesia (LA) is growing popular in recent years because of its safety, effectiveness and increased patient demands for minimally invasive procedures. To avoid neural injuries, local anesthesia that can keep the patient conscious is recommended. However, many patients complain about the severe pain during surgery. Epidural anesthesia (EA) is an alternative choice. We put forward an anesthetic method that combined preemptive analgesia (PA) and local anesthesia.

Objectives: The study aimed to assess the effectiveness of 3 methods of anesthesia for PTED, LA, EA and PA.

Study Design: A prospective study.

Methods: Three groups of patients were treated with standard PTED under LA, PA or EA, respectively. The data collected for analysis were operative time, x-ray exposure time, postoperative bed time, visual analog scale (VAS), Oswestry Back Pain Disability Index (ODI), the global outcome based on the Macnab outcome criteria, satisfaction rate of anesthesia, and complications.

Results: A total of 240 consecutive patients were enrolled in this study from January 2014 to December 2016. Among 3 groups, 1-week postoperatively VAS (back and leg) and ODI were improved compared with preoperative data, and the excellent/good rates were all above 90%. However, satisfaction rate of anesthesia showed significant differences among the 3 groups. PA and EA showed significantly better performance in pain management intraoperatively and 1 hour postoperatively. The operation time of group PA was the shortest and group EA was the longest. No severe neural injuries occurred in any of the 3 groups. Transient paresis of lower limbs occurred in all 3 groups and showed no significant differences. Decreased muscle strength of lower limbs postoperatively occurred in 2 patients in group EA. The incidence of nausea and vomiting postoperatively was significantly higher in group PA (6 cases, 7.50%). There were 3 cases of dysuria postoperatively in group EA (3.75%).

Limitation: First, this is a single center study. Second, this study investigated the effects of anesthesia on perioperative period and the follow-up time was relatively short. Third, we choose morphine in group PA and there are other types of anesthetics which may be used in preemptive analgesia in further study.

Conclusion: All 3 of these anesthetic methods are safe to avoid neural injuries. EA and PA showed better performance in pain management but had more anesthesia-related complications.

Key words: Percutaneous transforaminal endoscopic discectomy (PTED), local anesthesia, epidural anesthesia, preemptive analgesia, morphine, ropivacaine, pain management, visual analog scale (VAS), Oswestry Back Pain Disability Index (ODI)

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Percutaneous transforaminal endoscopic discectomy (PTED) under local anesthesia has grown popular in recent years because of its advanced endoscopic visualization and increased patient demands for minimally invasive procedures (1-3). Several randomized controlled studies have confirmed that it is a safe and effective procedure for soft disc herniation (4-8). Moreover, highly experienced surgeons have expanded the indications for PTED and have reported successful results even in cases with migrated disc herniation, foraminal/extraforaminal disc herniation, and disc herniation with spinal stenosis (3,9-13). Compared to open surgeries, PTED has the advantages of smaller incision, shorter operation time, lower estimated intraoperative blood loss, and fewer complications (2,6-8).

For PTED, as a percutaneous surgery with a steep learning curve, local anesthesia (LA) is recommended for avoiding nerve injury (8,14,15). LA can keep patients conscious during surgery. Thus, the surgeon can get feedback from patients when interfering with the nerve during surgery. However, through clinical observation, we found that some patients couldn't tolerate the pain during surgery, especially during the process of working channel insertion, foraminoplasty, and herniation discectomy. Besides, there was a reported study that neural irritation by insertion of instruments during PTED may cause severe pain, because of which the procedure may have to be stopped (8). Therefore, local anesthesia for PTED is still controversial. Epidural anesthesia (EA) is another major method which can keep patients awake during surgery. Through a reasonable choice of narcotic drugs and the control of sensory level, EA can prevent the pain but maintain the function of motor of lower limbs which is called sensory-motor separation. Preemptive analgesia is a new pain management concept that has been developed on the basis of the pathophysiology of acute pain (16). We put forward an anesthetic method that combined preemptive analgesia and local anesthesia (PA). Before surgery, we inject morphine 10mg intramuscularly to the patient and local anesthesia is performed intraoperatively. However, to our best knowledge, there is no study comparing the efficiency of these three anesthetic methods. Thus, we conducted a prospective study to assess the effectiveness of these 3 anesthetic methods.

Methods

General Information

This study was approved by the Ethics Committee of Shanghai Tenth People's Hospital. We enrolled 240 consecutive patients from January 1, 2014 to December 31, 2016. All patients were provided with consent forms, and the enrollment of patients is shown in Fig. 1. Each group included 80 patients who underwent PTED under LA, PA or EA, respectively.

The inclusion criteria were: 1) clinical evidence of soft disc herniation in a single segment; 2) intractable radicular symptoms such as sciatica, a positive straight-leg raising test, sensory and/or motor disturbances; 3) corroborative clinical and radiological findings; 4) more than 6 weeks of conservative treatment that failed to improve intractable leg pain, and functional impairments; 5) definite lumbar herniation with major weakness indicating urgent need for surgical decompression. The exclusion criteria were: 1) spinal malformations (congenital and external acquired) including scoliosis, lumbar sacralization, sacral lumbarization; 2) recurrent LDH; 3) multi segmental LDH; 4) accompanied by a wide range of lumbar spinal canal stenosis, cauda equina syndrome, and segmental instability including spondylolisthesis; 5) highly migrated type of LDH.

Surgical Procedure

In group LA, we infiltrated the skin with 1% lidocaine in 2-3 mL first and then an 18-gauge needle was introduced to anesthetize the trajectory with 8-10 mL lidocaine 1%. When the superior articular process was reached, 2-3 mL lidocaine 1% was used to anesthetize the facet joint. Lidocaine would be added intraoperatively if necessary. In group PA, morphine 10 mg was injected intramuscular half an hour before the surgery and then local anesthesia was the same as group LA. In group EA, the operation was performed by an experienced anesthesiologist according to the standard epidural anesthetic technique. The insertion point was 2 segments above the surgical segment. A total of 1% lidocaine 3 mL was applied initially and if the leg could move 5 minutes later, it indicated that the lidocaine was not in the subarachnoid space. The second time 0.25% ropivacaine was added to adjust the sensory level and achieve the aim of sensory-motor separation. The following operations were performed by one experienced surgeon according to the standard percutaneous transforaminal endoscopic spine system (TESSYS) (5).

Clinical Evaluation

The data collected for analysis were: operative time, x-ray exposure time, postoperative bed time, visual analog scale (VAS), Oswestry Back Pain Dis-

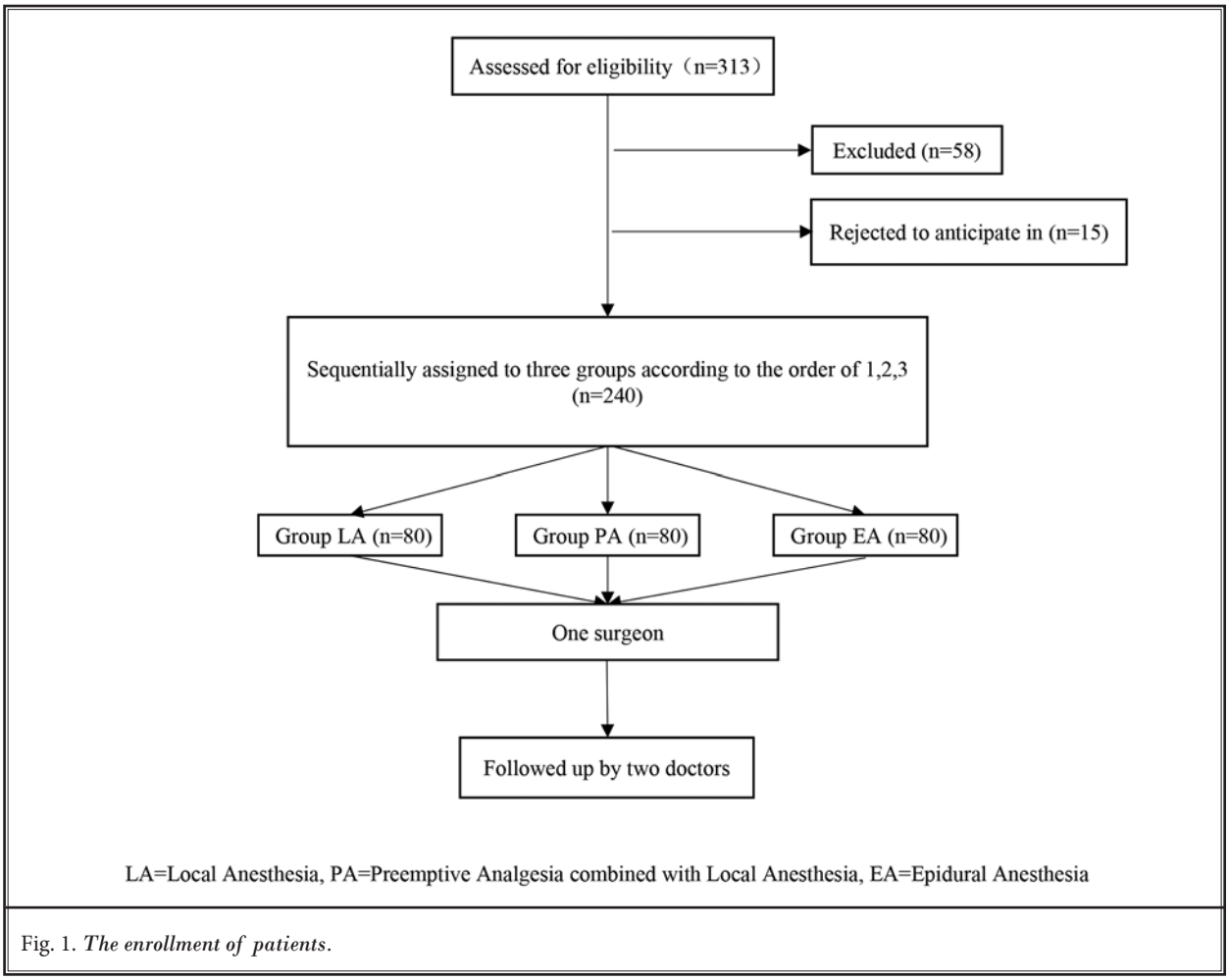

Fig. 1. *The enrollment of patients.*

ability Index (ODI), the global outcome based on the Macnab outcome criteria, satisfaction rate of anesthesia, and complications. Operating time included the procedures of anesthesia and surgeries. Back and leg pain was quantified by VAS collected from the patients preoperatively, intraoperatively, 1 hour postoperatively and 1 week postoperatively. The ODI, version 2.0, was used to evaluate how the patient's leg (or back) condition has affected his/her daily life preoperatively and 1 week postoperatively. The global outcome was assessed as excellent, good, fair, or poor based on the Macnab outcome criteria 1 week postoperatively. A favorable outcome was defined as excellent or good. Satisfaction rate of anesthesia was collected 1 hour postoperatively.

Statistical Assessments

The software of SPSS 21.0 (SPSS, USA) was used

Table 1. *Baseline characteristics of included patients among 3 groups.*

Demographic	Group LA	Group PA	Group EA	*P*
Gender				
Male	47	44	46	0.887
Female	33	36	34	
Mean age (yrs)	42 ± 16.32	41 ± 17.31	43 ± 20.42	0.554
Mean BMI (kg/m^2)	23.61 ± 6.22	22.56 ± 8.25	22.66 ± 7.46	0.089
Level of disk herniation				0.975
L2-3	2	1	1	
L3-4	15	16	13	
L4-5	29	32	33	
L5-S1	34	31	33	

BMI=body mass index, LA=local anesthesia, PA=preemptive analgesia combined with local anesthesia, EA=epidural anesthesia

for statistical analysis. One-way ANOVA was used to compare continuous variables (age, body mass index, operation time, x-ray exposure time, postoperative bedtime, VAS scores, ODI scores, etc). A chi-square test was used to compare the differences in gender, complication and satisfaction rates. All the data were showed in the form of mean ± standard deviation (SD). In all analyses, significance was defined as $P < 0.05$.

Results

Clinical Results

No significant differences existed among the 3 groups in terms of demographics (Table 1). The operation time of group LA was 63.19 ± 9.93 min, 57.08 ± 8.78 min for group PA, while group EA was 80.89 ± 8.65 min, which was longer than both group LA and group PA (‡$P < 0.001$,∫$P < 0.001$). The x-ray exposure time was 23.60 ± 3.11s in group LA, 22.8 6± 3.02s in group PA and 22.60 ± 3.10s in group EA. There were no significant differences among them ($P = 0.105$). The postoperative bed time showed no significant difference between group LA and PA (group LA = 117.92 ± 22.43 minutes, group PA = 122.16 ± 23.93 minutes, *$P > 0.05$) but group EA was significantly longer than both group LA and group PA (‡$P < 0.001$,∫$P < 0.001$).

According to the modified Macnab criteria, there were 41 cases of excellence, 31 cases of good, 5 cases of fair, and 3 cases of poor, with an excellence/good rate of 90.0% in group LA. In group PA, there were 43 cases of excellent, 31 cases of good, with an excellence/good rate of 92.5%. In group EA, the excellence/good rate was 93.8% including 45 cases of excellence and 30 cases of good. Satisfaction rate of anesthesia showed significant differences among the 3 groups (group LA = 72.5%, group PA = 85.0%, group EA = 90.0%). The ODI 1 week postoperatively showed no significant differences among the 3 groups. All these details of clinical data are illustrated in Table 2.

Preoperative VAS value of back pain (VAS-BP), leg pain (VAS-LP) and ODI were similar among the 3 groups. The intraoperative VAS-BP showed significant differences among them; group LA was 7.86 ± 0.59, while group PA and group EA were 5.19 ± 0.55 and 3.62 ± 0.55 respectively. One hour and 1 week postoperative VAS-BP of group LA was significantly higher than both group PA and group EA. One hour postoperative VAS-BP of group PA showed a significant difference

Table 2. *Comparison of clinical outcomes among 3 groups.*

Patients	Group LA	Group PA	Group EA	*P*
Operation	63.19 ± 9.93	57.08 ± 8.78	80.89 ± 8.65	< 0.001*
Time(minutes)		(‡$P < 0.001$)	(‡$P < 0.001$, ∫$P < 0.001$)	
X-ray exposure(seconds)	23.60 ± 3.11	22.86 ± 3.02	22.60 ± 3.10	0.105
Postoperative	117.92 ± 22.43	122.16 ± 23.93	353.69 ± 24.31	< 0.001*
Bed time (minutes)			(‡$P < 0.001$, ∫$P < 0.001$)	
Macnab satisfaction				
Excellent	41	43	45	0.924
Good	31	31	30	
Fair	5	5	4	
Poor	3	1	1	
Satisfaction rate of anesthesia	58 (72.5%)	68 (85.0%)	72 (90.0%)	< 0.05*
		(‡$P < 0.05$)	(‡$P < 0.05$, ∫$P < 0.05$)	
Complications	2	7	10	0.014*
Nerve injury	0	0	0	
Transient paresis	2	1	4	
Decreased muscle strength of lower limbs	0	0	2	
Nausea and Vomiting	0	6	1	
Dysuria	0	0	3	

Compared with LA, ‡$P < 0.05$; Compared with PA,∫$P < 0.05$; Comparison among 3 groups, *$P < 0.05$; LA=local anesthesia, PA=preemptive analgesia combined with local anesthesia, EA=epidural anesthesia

Table 3. *Comparison of patient-reported outcomes among 3 groups.*

	Group LA	Group PA	Group EA	*P*
VAS of back pain				
Preoperative	2.64 ± 1.55	2.70 ± 1.25	2.83 ± 1.59	0.714
Intraoperative	7.86 ± 0.59	5.19 ± 0.55	3.62 ± 0.55	< 0.001*
		(‡P < 0.001)	(‡P < 0.001, ∫P < 0.001)	
Postoperative (1 hour)	3.80 ± 0.25	2.54 ± 0.25	1.87 ± 0.22	< 0.001*
		(‡P < 0.001)	(‡P < 0.001, ∫P < 0.001)	
Postoperative (1 week)	1.47 ± 0.27	0.99 ± 0.22	1.01 ± 0.22	< 0.001*
		(‡P < 0.001)	(‡P < 0.001)	
VAS of leg pain				
Preoperative	7.27 ± 1.69	7.46 ± 1.52	7.31 ± 1.41	0.09
Intraoperative	6.87 ± 0.51	5.94 ± 0.48	2.47 ± 0.51	< 0.001*
		(‡P < 0.001)	(‡P < 0.001, ∫P < 0.001)	
Postoperative (1 hour)	3.15 ± 0.36	1.93 ± 0.41	1.23 ± 0.30	< 0.001*
		(‡P < 0.001)	(‡P < 0.001, ∫P < 0.001)	
Postoperative (1 week)	3.06 ± 0.73	2.49 ± 0.80	2.02 ± 0.76	< 0.001*
		(‡P < 0.001)	(‡P < 0.001, ∫P < 0.001)	
ODI				
Preoperative	60.53 ± 5.68	61.62 ± 5.87	62.40 ± 5.51	0.116
Postoperative (1 week)	17.77 ± 8.57	17.26 ± 9.47	14.77 ± 8.61	0.08

Compared with LA, ‡P < 0.05; Compared with PA, ∫P < 0.05; Comparison among three groups, *P < 0.05; LA=local anesthesia, PA=preemptive analgesia combined with local anesthesia, EA=epidural anesthesia; VAS, visual analog scale; ODI, Oswestry Back Pain Disability Index

with group EA while 1 week postoperative showed no significant difference. The intraoperative, 1 hour postoperative and 1 week postoperative, VAS-LP showed significant differences among the 3 groups; group EA was the lowest while group LA was the highest. One week postoperative ODI showed no significant differences among these three groups (P = 0.08). All these details are illustrated in Table 3.

Complications

Four cases of transient paresis of lower limbs occurred in group EA, while 2 cases of transient paresis occurred in group LA and 1 case in group PA. Decreased muscle strength of lower limbs postoperatively occurred in 2 patients in group EA. The incidence of nausea and vomiting postoperatively was significantly higher in group PA (6 cases, 7.50%). There were 3 cases of dysuria postoperatively in group EA (3.75%).

Discussion

Our results confirmed that PA and EA more effectively manage the intraoperative pain but the anesthesia-related complication rates were higher than LA comparatively.

Effective and efficient pain management strategies have the potential to improve medical outcomes, enhance patient satisfaction, and reduce costs (17). Thus, pain management is important for PTED. LA has the advantage of being a simpler procedure with less anesthesia-related complications. However, the effectiveness of LA to manage intraoperative pain is poor. Low concentrations of epidural ropivacaine could prevent pain effectively during surgery but maintain the motor function of lower limbs thus the surgeon can still get feedback from the patient. However, compared to LA, the EA procedure is more complicated and prolongs operation time and postoperative bed time. Besides, EA increases the risk of anesthesia-related complications like urinary retention.

Opioid medicines are the most commonly used analgesics in history (18). Before the surgery, we injected morphine 10 mg intramuscularly to the patient. Compared to local anesthesia, PA was more effective in preventing the intraoperative pain while not being as complicated as EA. However, morphine has side-effects, which must be accounted for.

Intraoperative back pain in PETD occurs mainly

from the insertion of the working channel, especially for foraminoplasty, which is needed for reaching the ideal location because of the high iliac crest, large facet joint, and disc space inclinatory (19). Intraoperative leg pain occurs mainly from the stimulation of the nerve either in the process of working channel insertion or decompression of herniation especially for huge herniations. For those patients with huge herniations, the working channel may increase the compression of the herniation to the nerve. Most patients who were dissatisfied with the surgery under local anesthesia complained about pain during the surgery, which indicated that the effectiveness of local anesthesia has been limited. The management of leg pain was poor in group LA and group PA as the sensory function of the nerve remains during the procedure. However, leg pain of group PA was still lower than group LA mainly thanks to the preoperative morphine. EA showed a satisfactory pain management because of the sensory-motor separation. One-hour postoperative VAS-BP and VAS-LP of group PA and group EA showed significant differences with group LA. Most patients were satisfied with the surgeries 1 week postoperatively as the excellence/good rate of the 3 groups were all above 90%. However, the satisfaction rate of anesthesia showed significant differences among 3 groups with group LA being the lowest.

The operation time and x-ray exposure time were closely related to the cooperation of patients. The management of intraoperative pain was the major factor as the process would stop when the patients could not endure the pain. Although x-ray exposure time showed no significant differences among three groups, we still found in surgeries that the better intraoperative pain was prevented, the less x-ray exposure time. The damage of radiation exposure induced by repeated fluoroscopy cannot be ignored during surgeries. The International Commission on Radiological Protection (ICRP) has recommended radiation limits per year for professionals, specialized body tissues and organs (20). The operation time in group EA was the longest as it took about twenty minutes for these procedures. Also, the postoperative bed time of group EA was the longest because 6 hours' bed rest in the horizontal position is recommended for patients following EA.

It's necessary to keep patients conscious during PTED surgery to minimize nerve root injuries, especially for inexperienced surgeons. That's the reason why general anesthesia is not recommended for PTED. When the nerve root was irritated, patients in group LA and group PA could inform the surgeons in time. Because the lower limbs' motor function of patients in group EA could be preserved by low concentration ropivacaine, surgeons could detect the nerve injury by observing the movement of the patients' toes. Except for 7 cases of transient paresis, no severe neural injuries occurred in any of the patients included in our study. The transient paresis might be caused by the irritation of nerve root during the removal of herniated disc tissue. Considering that the symptoms alleviated within 6 hours, an excessive dose of ropivacaine might be responsible for the 2 cases of postoperative decreased muscle strength of lower limbs in group EA. The higher rate of complications likes nausea and vomiting in group PA , which are common side effects of opioid drugs, could be explained by the utilization of morphine. As for the 3 cases of dysuria in group EA, it's a common side effect of EA that normally disappears in hours.

In addition, respiratory depression and hypotension are side effects of morphine which need to be considered even though they didn't occur in this study, especially for the elderly. In the case of EA, an experienced anesthesiologist is recommended to avoid spinal cord damage/cauda equina damage and for control sensory-motor separation. As for LA, too much lidocaine on the facet joint can easily anesthetize the nerve root thus losing direct nerve root feedback from the patient and increasing the risk of nerve injuries. For this reason, a proper choice of anesthesia for PTED tailored to the patient is important.

Our study had several limitations. First, this is a single center study. Second, this study investigated the effects of anesthesia on the perioperative period and the follow-up time was short. Third, we choose morphine in group PA and there are other types of anesthetics which may be used in PA in future studies.

Conclusion

For PETD, all these 3 anesthetic methods (LA, EA, and PA) can get a good clinical results. PA and EA showed a significantly better performance in intraoperative pain management than LA. However, the side-effects of morphine and epidural anesthesia should be considered carefully.

Author Contributions

Dr. Gu had full access to all the data in the study and takes responsibility for the integrity of data and the accuracy of the data analysis. Dr. He, Dr. Zhu, and Dr. Sun designed the study protocol. Dr. Zhu managed

the literature searches and summaries of previous related work and wrote the first draft of the manuscript. Dr. Zhou and Dr. Wang collected the data. Dr. Zhao performed the data analysis. Dr. Fan provided revision for intellectual content and final approval of the manuscript.

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