Retrospective Review

Unique Complications of Percutaneous Endoscopic Lumbar Discectomy and Percutaneous Endoscopic Interlaminar Discectomy

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Background: Percutaneous endoscopic discectomy (PED) includes 2 main procedures: percutaneous endoscopic lumbar discectomy (PELD) and percutaneous endoscopic interlaminar discectomy (PEID), both of which are minimally invasive surgical procedures that effectively deal with lumbar degenerative disorders. Because of the challenging learning curve for the surgeon and the individual characteristics of each patient, preventing and avoiding complications is difficult. The most common complications, such as nucleus pulposus omission, nerve root injury, dural tear, visceral injury, nerve root induced hyperalgesia or burning-like nerve root pain, postoperative dysesthesia, posterior neck pain, and surgical site infection, are difficult to avoid; however, more focus on these issues perioperatively may be in order. Additionally, unique and unexpected complications can also occur, such as retroperitoneal hematoma (RPH), intraoperative seizures, and thrombophlebitis, among others.

Objective: We aim to delineate unique complications during PED and accumulate strategies to prevent significant morbidity and improve surgical techniques.

Study Design: A retrospective cohort study of patients undergoing PEID or PELD from October 2014 to January 2016.

Setting: Affiliated hospitals of Qingdao University.

Methods: Patients with lumbar disc herniation (LDH) who underwent PEID and PELD were retrospectively analyzed. Complications were recorded and analyzed pre and postoperatively. We assessed clinical outcomes using the visual analog scale (VAS) and Oswestry Disability Index (ODI) and classified the results into "excellent," "good," "fair," or "poor" based on the modified MacNab criteria. All of the patients were followed for more than one year to evaluate their recovery from complications.

Results: From October 2014 to January 2016, 426 patients with LDH underwent PEID (106 cases) or PELD (320 cases). Common complications and occurrence rates were as follows: the incomplete removal of herniated discs was 1.4% (6/426), recurrence 2.8% (12/426), nerve root injury 1.2% (5/426), dural tear 0.9% (4/426), and nerve root induced hyperalgesia or burning-like nerve root pain 2.3% (10/426); no posterior neck pain or surgical site infection occurred. Unique complications included: passage of the working channel through the spinal canal into the disc space (one case), super-elastic nerve hook caught by exiting nerve root (one case), epidural hematoma (one case), radicular artery injury and massive bleeding (one case) which was revised by micro-endoscopic discectomy, and intraoperative seizure (one case). No serious consequences occurred after active medical intervention, and most patients had good recovery by 3 months postoperatively with physical therapy.

Limitations: The main limitations of this study are the retrospective study design, limited case number, and short follow-up period.

Conclusions: PEDs are effective and minimally invasive methods for the surgical treatment of LDH, causing fewer complications due to the very minimal operational trauma for the muscle-ligament complex and stability of the spine. Nevertheless, because of the difficult learning curve for surgeons, lack of experience with the requisite surgical techniques, and enhanced clinical responsibility, a variety of problems may occur. Especially concerning are the unique complications mentioned here, which potentially lead to severe injury for the patient and require diligent preventive measures.

Key words: Unique complications, epidural, hematoma, interlaminar, transforaminal, PEID, PELD

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Percutaneous endoscopic lumbar discectomy (PELD) and percutaneous endoscopic interlaminar discectomy (PEID) have become routinely performed minimally invasive spinal procedures for lumbar degenerative disorders. However, several complications have attracted our concern, such as nucleus pulposus herniation, nerve root injury, dural tear, retroperitoneal hematoma (RPH), visceral injury, nerve root induced hyperalgesia or burning-like nerve root pain, postoperative dysesthesia, intraoperative seizure, posterior neck pain, thrombophlebitis, and surgical site infection. These complications possibly result from various factors such as the challenging learning curve for surgeons, lack of appropriately skilled surgeons, challenging surgical techniques, poor postoperative follow-up, and other similar factors (1-6). In a multicenter study of over 26,000 cases combining percutaneous fluoroscopic techniques with endoscopic spine surgery, the overall complication rate of percutaneous endoscopic discectomy (PED) was less than 1%: 1) dysesthesia 0.45%, 2) cerebrospinal fluid leak 0.17%, 3) discitis 0.25%, 4) motor or sensory loss 0.32%, and 5) recurrence 0.79% (7). Another retrospective review including 10,228 cases indicated a failure rate of 4.3%, incomplete removal of herniated discs 2.8%, recurrence rate 0.8%, persistent pain after complete herniated disc removal 0.4%, and approach-related surgical site pain 0.2% (8).

It was difficult to distinguish between minor and severe complications, as each were reported frequently. Moreover, few published studies discuss unique and rare complications, which are always deemed unreasonable. The purpose of this study is to report several unique complications to present our cumulative experience and improve preventive techniques going forward.

Methods

Patients

Between October 2014 and January 2016, 456 patients with lumbar disc herniation (LDH) who underwent PEID or PELD by one spine department, which had 2,600 open and 1,000 minimally invasive spine surgeries, were retrospectively analyzed, and the patients were followed for more than one year postoperatively. Neurological examinations, pre-operative computed tomography (CT), and magnetic resonance imaging (MRI) studies were used to identify the location and type of LDH. The cases had the following characteristics: 320 PELD cases were completed with local anesthesia and 136 PEID cases were performed with local anesthesia (45 cases), general anesthesia (51 cases), or modified sensation-motion separation anesthesia (40 cases), respectively. Among 456 consecutive cases, 30 cases were lost at the final follow-up because of address changes or incorrect information. Among 426 cases with detailed clinical data that were followed-up strictly, 5 cases incurred unique complications during the operation (Table 1). Clinical outcomes were evaluated with the visual analog scale (VAS) and Oswestry Disability Index (ODI) and were further classified into "excellent," "good," "fair," or "poor," based on the modified MacNab criteria.

Surgical Methods

PELD

Standard PELD was performed under local anesthesia (9). The patients were kept in the prone

Table 1. *Demographic and clinical features of 5 cases with unique complications.*

Case No.	Complication	Gender/ Age (yrs)	Level	Procedure	Intraoperative Symptoms	Treatment	Anesthesia	Treatment
1	Working channel displacement	Male/39	L5/S1	PEID	Normal	36/45 (80%)	General	Replacement
2	Nerve hook entangled	Male/69	L4/5	PELD	Exiting nerve root injury	39/50 (78%)	Local	Removed with fluoroscopy
3	Epidural hematoma	Female/72	L4/5, L5/S1	PELD	Hypertension, back and neck pain	34/50 (68%)	Local	Anti-hypertensive, sedation, analgesic medications
4	Artery injury	Male/41	L4/5	PELD	Hemorrhagic shock	38/50 (76%)	Local	Hemostasis, revision
5	Seizure	Male/26	L4/5	PELD	Constricted feeling saddle distribution, seizure	33/45 (73.3%)	Local	Sedation, analgesia

PEID = percutaneous endoscopic interlaminar discectomy; PELD = percutaneous endoscopic lumbar discectomy

position with knee and hip joints flexion to enlarge the intervertebral foramen indirectly. A C-arm was placed near the head and perpendicular to the patient to get absolutely frontal and lateral x-ray images. A fluoroscopic-guided, postero-lateral, transforaminal approach through the foraminal window was performed. The decision regarding foraminoplasty was decided according to the position of the disc and foramen condition, and when necessary, a reamer or bone drill was used. After a safe transforaminal approach, a suitable working channel endoscope was inserted, and under direct visualization and irrigation, the ligamentum flavum was dissected or removed to permit endoscopic access to the spinal cord. Discectomy was then performed first by releasing the intra-annular disc attachments to the sequestered disc, and the herniated fragment was slowly removed from the spinal canal with forceps.

After complete discectomy and decompression, fluid dural pulsations returned. A radiofrequency bipolar coagulator was used to coagulate bleeding vessels and the injured annulus fibrosus. At the end of the procedure, the disc space, canal, and intervertebral foramen were visually inspected while gradually retrieving the working channel and endoscope.

PEID

The patients were kept in the prone position with knee and hip joint flexion to increase the interlaminar space. A posterior transverse incision with the length of 7 mm was made about 5 mm adjacent to the spinous process. Each surgical procedure was carried out differently per the anesthesia regimen used as described hereafter. With local anesthesia, patients underwent PEID after local injection of lidocaine mixed with ropivacaine. The surgical team and patient communicated directly throughout the procedure with frequent pain threshold assessments to ensure comfort. Next, the puncture needle was advanced to the herniated disc directly, and a working channel was placed according to the technique of Professor Choi (10). With general or continuous epidural anesthesia, because the patient was unconscious, the puncture needle and working channel had to be placed outside of the ligmentum flavum. We then dissected or separated the ligmentum flavum, exposing adjacent nerve roots and herniated disc material, completing the remainder of the discectomy endoscopically according to the procedure of Professor Rutten (11,12).

Results

Of 426 patients who were followed-up strictly, 37 (8.7%) experienced a variety of the most frequently reported complications with PEID and PELD. Common complications and occurrence rates were as follows: the incomplete removal of herniated discs was 1.4% (6/426), recurrence 2.8% (12/426), nerve root injury 1.2% (5/426), dural tear 0.9% (4/426), and nerve root induced hyperalgesia or burning-like nerve root pain 2.3% (10/426); there were no instances of posterior neck pain or surgical site infection.

In a small number of cases, 5 (1.2%) patients experienced unique complications, which were rarely reported before. These included: the working channel passing through the canal into the disc space (one case) (Fig. 1), super-elastic nerve hook trapped by exiting nerve root (one case) (Fig. 2), epidural hematoma (one case) (Fig. 3), radicular artery injury and massive bleeding (one case) (Fig. 4), and intraoperative seizure (one case). No severe consequences occurred after active medical intervention, and most of the patients had a good recovery in the 3 months postoperatively with physical therapy. Based on the modified MacNab criteria, the final outcome was found to be "good" in 3 patients and "poor" in 2 patients (Table 2).

Discussion

PELD and PEID have been hailed as among the newest and best methods for minimally invasive surgery in the treatment of degenerative lumbar disorders. Although problems are unusual and infrequent, the potential complications associated with this procedure should be noted, especially those that are surprising and unexpected.

Hilbert et al (13) reported massive dyspnea in combination with severe abdominal pain after endoscopic discectomy. Sonographically detected fluid proved to be surgical irrigation solution after CT-guided puncture. Chang et al (14) reported left internal iliac artery and vein tear during microendoscopic lumbar discectomy. Sairyo and colleagues (4) reported one in 100 cases with post-surgical epidural hematoma during PELD that required surgical removal of the mass (1.0%). Tonosu et al (15) reported persistent numbness in the corresponding nerve area, transient muscular weakness, and transient bladder and rectal disturbance, due to excessive compression of the nerve root and/or dural sac by the endoscopic sheath in 3 patients in a cohort of 41 cases treated by interlaminar approach via the shoulder.

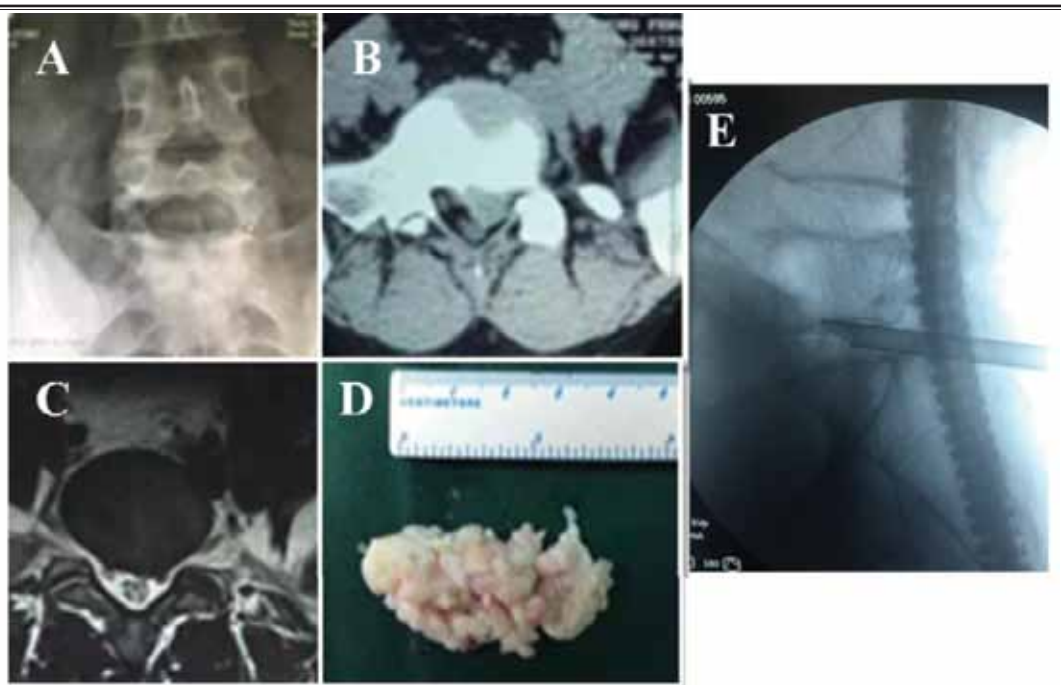

Fig. 1. *Case illustration of working channel in the disc space. A 39-year-old male patient underwent PEID with general anesthesia for L5-S1, left-sided disc herniation. The interlaminar space was wide enough on the anteroposterior radiograph (A); transverse CT scans (B); MRI demonstrating L5-S1 disc protrusion (C); the herniated disc was removed (D); lateral radiograph showing the working channel deeply inserted into the disc space (E).*

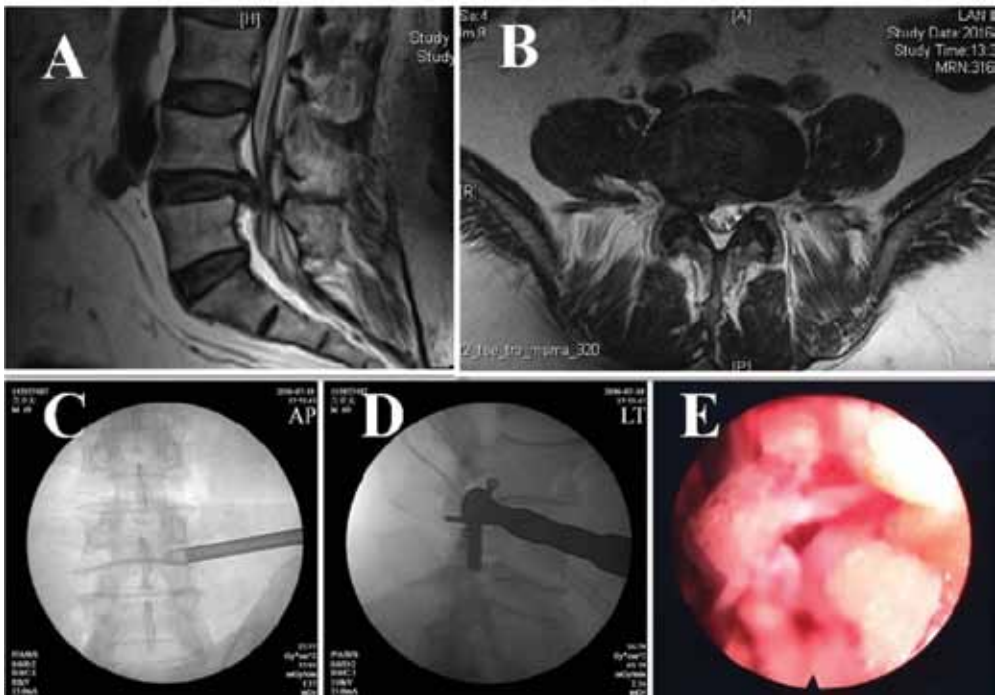

Fig. 2. *Case illustration of the nerve hook. A 69-year-old male patient underwent PELD for L4-5 right-sided disc herniation. Sagittal (A); transverse MRI demonstrating L4-5 disc protrusion (B); fluoroscopy confirmed on the anteroposterior and lateral views that the working channel was located at the tip of superior facet and traveled inside of intervertebral foramen (C and D, respectively); the exiting nerve root was destroyed by the super-elastic nerve hook (E).*

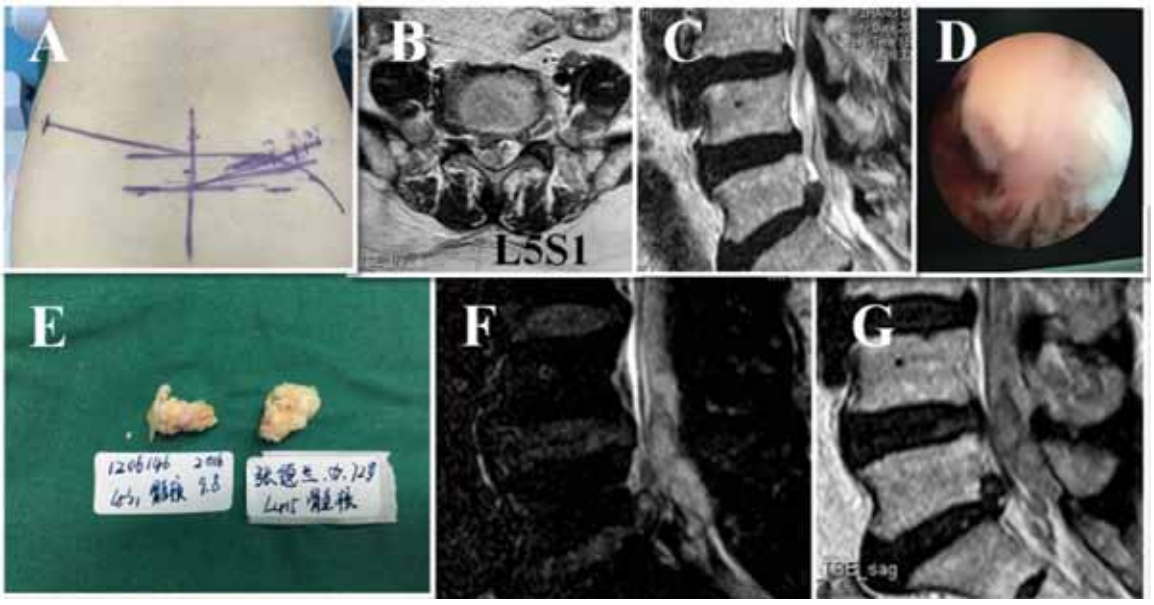

Fig. 3. *Case illustration of epidural hematoma. A 72-year-old female patient with hypertension and coronary heart disease for 20 years underwent PELD for right-sided disc herniation at the L5-S1 level and left-sided at L4-5 level. Pre-operative incision planned at the L4-5, L5-S1 spaces (A); axial (B) and sagittal (C) MRI showing the sequestrated L5-S1 disc; intraoperative sequestrated disc (D); postoperatively dissected disc (E); postoperative sagittal MRI, demonstrating an epidural hematoma (F, G).*

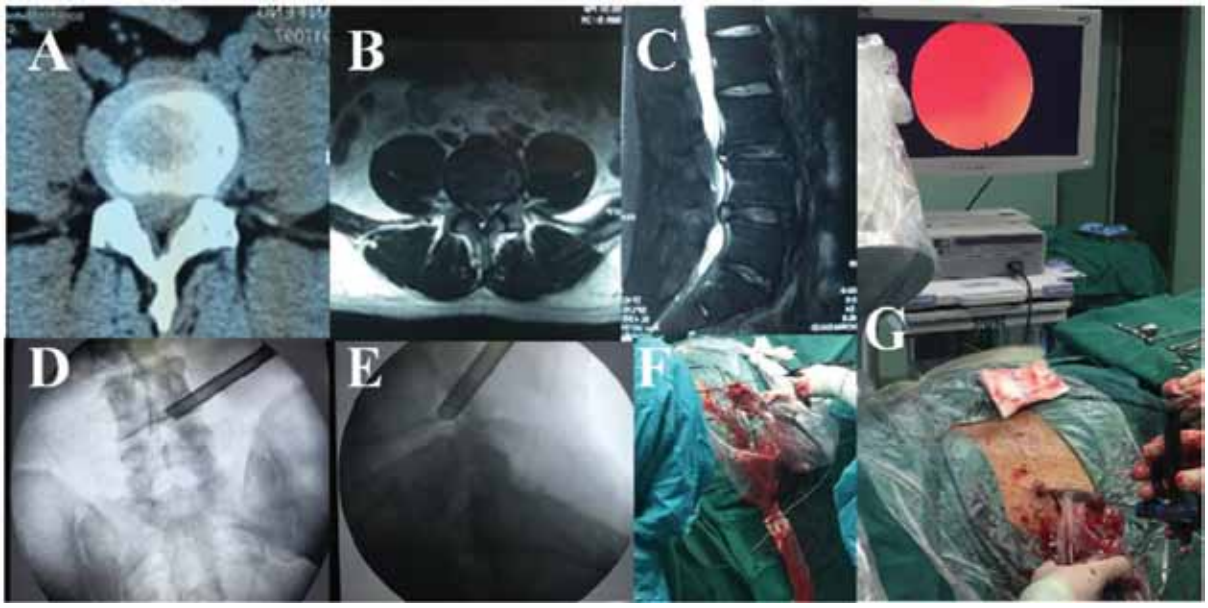

Fig. 4. *Case illustration of a radicular artery injury. A 41-year-old male underwent PELD for right-sided, L4-5 disc herniation. Axial CT (A) and MRI (B); sagittal MRI demonstrating L4-5 disc protrusion (C); fluoroscopic verification confirmed that on the anteroposterior and lateral view, the working channel was located at the tip of the superior facet and traveled inside of intervertebral foramen (D and E, respectively); the radicular artery accompanying the right L4 exiting nerve root was destroyed and followed by hemorrhage (E and F, respectively).*

Table 2. *Clinical outcomes of 5 cases with unique complications.*

Case No.	Pre-VAS Leg)	Post-VAS (Leg)	Pre-VAS (Back)	Post-VAS (Back)	Pre- ODI	Post-ODI	MacNab
1. Working channel	8	1	7	2	36/45 (80%)	9/45 (20%)	Good
2. Nerve hook	9	2	8	2	39/50 (78%)	15/50 (30%)	Good
3. Epidural hematoma	9	3	7	3	34/50 (68%)	27/50 (54%)	Poor
4. Artery injury	8	5	6	4	38/50 (76%)	25/45 (55.6%)	Poor
5. Seizure	7	1	5	2	33/45 (73.3%)	9/45 (20%)	Good

VAS = visual analog scale; ODI = Oswestry Disasbility Index

Guan et al (16) published 2 cases with guide wire breakage during PELD. In these instances, the operator inserted the working cannula to the broken end of the guide wire and retrieved it with straight grasping forceps under endoscopy. Tamaki and colleagues (17) published a case of an intradural LDH at L4-5 with PELD performed twice, resulting in a dural tear that was technically difficult to repair. Postoperative MRI and myelography revealed an intradural LDH. The herniated mass was removed by durotomy, with subsequent posterior lumbar interbody fusion. Ahn and colleagues (18) reported 4 cases with postoperative retroperitoneal hematoma following PELD in 412 consecutive patients. The mean hematoma volume was 527.9 mL, and 2 patients with massive, diffuse-type RPHs compressing intra-abdominal structures required open hematoma evacuation by general surgeons. In this series, the other 2 patients with small, localized RPHs of < 100 mL were treated conservatively.

Our study demonstrates 5 kinds of unique complications, most of which were rarely reported before. We found that the best option for dealing with these types of complications is preventative, and we have focused on such strategies here. PEID as an alternative and efficient procedure can be widely used to deal with lumbar degenerative diseases.

The anesthesia regimen will greatly affect safety and complication rates with their attendant clinical results. Local anesthesia is an excellent alternative for PEID, as it does not interfere with accurate surgical techniques and does not compromise pain tolerance. Modified sensation-motion separation anesthesia is suitable and safe for surgeons new to PELD, due to the high safety and tolerability for patients. General anesthesia is feasible in PEID, but is associated with relatively high complication rates. In our study, after general anesthesia induction, when the patient is completely unconscious, our surgeons found it difficult to distinguish the herniated disc and to move the working channel after connecting the endoscope. We fluoroscopically identified that the working channel was unexpectedly inserted into the spinal canal through the widened interlaminar space. Under endoscopy, the working channel was retracted to the normal position, and no dural tear or nerve root injury was found. Our experience shows that firstly, the surgeon should be capable of autonomously using the equipment--that is without an assistant holding the working channel, and secondly, fluoroscopy can ensure safety at any step of endoscopic procedures.

Among several challenges, the surgeon did not monitor positioning of the working channel with fluoroscopy, causing its misplacement, which led to nerve hook issues and radicular artery injury. After several lumbar punctures, the working channel was perched on the tip of the superior facet without foraminoplasty. Another shortcoming was failing to appreciate the difficulty of understanding local anatomy as viewed through the endoscope, mistaking the exiting nerve root for the traversing nerve root, and attempting to find the herniated disc with a super-elastic nerve hook without success. Moreover, the hook was placed too deep, catching the elastic tip on the exiting nerve root, and any attempt to retrieve the instrument caused a sharp pain in the contralateral sciatic nerve distribution. Assistance from another experienced surgeon to determine the position of the nerve hook with fluoroscopy, adjust its direction, and finally remove it was invaluable as it allowed the original operator to replace the working channel. Subsequently, the discectomy was completed well, and fortunately, no neurological deficits occurred postoperatively.

In another case, the radicular artery and the exiting nerve root were destroyed by repeated puncture and placement of the working channel. Several attempts to staunch the bleeding persisted for 40 minutes but failed; the patient exhibited symptoms of hemorrhagic shock including hypotension, heavy cold sweats, and restless-

ness. Normal saline and colloidal solutions were used emergently and hemostatic sponges were placed into the foramen for effective hemostasis. The patient was revised by microendoscopic discectomy the next day.

The risk of developing intraoperative seizures has not been investigated to date, though increased epidural pressure during PELD has been reported earlier and may be related to this complication. Shin et al (19) reported a case of non-epileptic seizure onset during emergence from general anesthesia; the patient subsequently developed Takotsubo cardiomyopathy. Choi and colleagues (6) demonstrated that 4 of the total 16,725 patients who underwent PELD developed intraoperative seizures.

A striking feature of the 4 patients in the above series was that they all complained of neck pain before the seizure event. Although rare (0.02%), seizures can occur in patients undergoing PELD, and the occurrence of neck pain is correlated with an increase in cervical epidural pressure. This should be considered a prodromal sign, prompting an alert to the surgeon. The duration of the procedure and speed of drug infusion are associated risk factors for intraoperative seizures (6).

Kertmen et al (20) presented the first case of seizure after transforaminal PELD, which was caused by inadvertent administration of the contrast media into the thecal sac. They also hypothesized that the mechanism of seizure induction is either due to neurotoxic effects or an idiosyncratic reaction. In their study, one case with L4-5 disc herniation developed seizure activity during the PELD. When the endoscope was inserted at the intended level and the discectomy completed, the patient complained about a constricted feeling around the saddle area, followed by severe low back and neck pain, followed by limb convulsions and hypertension. The anesthetists were immediately notified and they administered inhaled oxygen, sedation, and analgesia. After 2 hours, the patient returned to normal and had good neurological recovery. When the patient was admitted to the ward, cerebrospinal fluid leaked out of the incision. This could explain the witnessed complication—possibly due to a dural tear, combined with continuous infusion of fluids and medication, along with a highly increased cervical epidural pressure.

Sairyo et al (4) discusses surgery related complications in the initial 100 cases from a single surgeon. One case showed postoperative epidural hematoma and required surgical removal of the mass (1.0%), a known complication of the postero-lateral PED procedure. In our study, one patient underwent 2-level PELD for less than 2 hours in the L4-5 disc space first. The L5-S1 sequestered disc removal was well tolerated; however, after a short while, the patient complained of severe low back pain followed by neck pain. Monitors recorded hypertension to approximately 260/160 mmHg, and the patient was placed supine immediately. Our anesthesia colleagues administered anti-hypertensive medications, sedation, and analgesia. One hour later, the patient was recovering well with only mild, left-sided low back pain (4).

Limitations existed secondary to operative techniques, surgeon experience, and recording methods among other factors. For our spine department, PED was carried out over a relatively short time period with restricted accrual of cases; this was likely the main reason for the unique complications reported here.

Conclusions

PED is a set of effective and minimally invasive methods to deal with LDH. The strength of these procedures is that they cause fewer complications due to miniscule operational trauma for the muscle-ligament complex and stability of the spine. Nevertheless, because of the difficult learning curve and the lack of skill with requisite surgical techniques and clinical care of postoperative patients, different kinds of problems can arise with some frequency, especially when unique complications cause severe injury for the patient. Surgeons should vigilantly make adequate technical considerations and thoroughly understand patient anatomy to avoid unusual complications. Also, a high index of suspicion and early detection are important to prevent progressive neurological deficits or other adverse events.

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