Percutaneous fully endoscopic surgical management of the ruptured epidural catheter: Rescue of the young anesthesiologist from his dilemma

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Abstract

Background

Epidural nerve block and analgesia are basic operation techniques for anesthesia. Epidural catheter rupture and partial retention are adverse events and rare complications of epidural catheterization technology. The probability of occurrence when applied by young doctors is high. Removal of the residual catheter by conventional surgery causes more trauma and bleeding, slows recovery, and causes medical disputes. These events also challenge the growth of young doctors. Some hospitals have almost eliminated this operation technique. All surgical patients undergo intubation and general anesthesia, which greatly wastes medical resources and increases patient costs.

Objective

To analyze the efficacy and safety of removing the residual dural catheter by a percutaneous endoscopic technique and discuss the clinical technique and precautions.

Methods

This was a retrospective analysis of 7 patients with ruptured epidural catheters treated in our department from October 2015 to October 2019 using the percutaneous spinal endoscopic technique to remove the remaining epidural catheter. The operation time, intraoperative bleeding volume, surgical complications, and neurological symptoms before and after surgery were recorded. The Self-Rating Anxiety Scale (SAS) was used to assess the anxiety level of the anesthesiologist and the patient before and after the catheter removal operation, and the postoperative low back pain VAS score was recorded.

Results

The remaining epidural catheter was successfully removed from all 7 patients. The operation time was 54.14 ± 14.45 (32–78) minutes, and the intraoperative blood loss was 9.134 ± 3.078 (5–15) ml. There were no cases of dural damage, cerebrospinal fluid leakage, sensorimotor dysfunction of the lower limbs, or bowel dysfunction. The anxiety symptoms of the patient and the anesthesiologist disappeared after removal of the residual epidural catheter. The patients' postoperative back pain VAS score was 0 to 2 points.

Conclusion

Percutaneous spinal endoscopy is a safe and effective minimally invasive technique for removing residual epidural catheters. It causes less trauma and less bleeding, allows a faster recovery, and has a

low cost. It does not affect the recovery of patients from other surgical operations and reduces both medical risks and medical costs. At the same time, it avoids or reduces the occurrence of medical disputes and eliminates the pressure on young anesthesiologists regarding similar adverse events.

Foreword

Epidural puncture is a basic operation technique for anesthesia and is one of the most effective and safest methods for analgesia in labor and delivery[1]. It is also the most widely used, reliable and feasible method for analgesia, with an efficacy of over 95%[2]. At present, the continuous epidural block method is a basic technique for anesthesia that it is widely used, especially in county-level hospitals, in patients with controlled analgesia, chronic low back pain, labor pain, etc. This method is widely used to implement feasible epidural analgesia [3, 4]. Therefore, rupture and partial retention of the epidural catheter have become common adverse events and complications of clinical anesthesia. Related research has shown that the incidence of catheter rupture during epidural anesthesia is 0.1–0.3% [3, 5].

There are many reasons for epidural catheter rupture and partial retention, but most scholars believe that improper operation is the main cause of catheter rupture. The most common cause of epidural catheter rupture is insufficient operation experience in young doctors[6]. First, when resistance is encountered during catheter placement in the epidural space, the catheter is directly withdrawn from the inside of the needle, causing the catheter to be cut and broken by the puncture needle. Second, after successful puncture and catheterization, the technique of retracting the needle sheath while advancing the catheter is not performed, and the needle is instead quickly withdrawn directly, causing the tip of the puncture needle sheath to cut the catheter. Third, when the catheter is removed at the end of the operation, the operator exerts rapid force, causing the catheter to break. Of course, there are other special conditions, such as catheter quality problems, uninspected catheters with damage, patients with ligamentous calcification of the ligamentum flavum or hypertrophic arthritis, catheter clipping and trimming during the operation, and rarely, epidural catheter knotting[5, 6, 7, 8].

At present, there is no unified opinion regarding the treatment of catheter breakage during epidural anesthesia or analgesia[1, 3]. When the stump is located under the skin, it is recommended to make a local skin incision to remove it. When the stump is located in the spinal canal, the lamina needs to be surgically removed to find the catheter, causing extensive surgical trauma and bleeding, which leads to the destruction of local spinal stability; thus, it is recommended to continue with observation and no operation in the absence of clinical symptoms. A piece of ruptured catheter in the epidural space is a foreign body, which will cause related inflammatory hyperplastic reactions, the formation of a foreign body granuloma, and the occurrence of related nerve compression symptoms and signs[8, 9]. Considering surgical treatment, the difficulty and risk of surgery are significantly increased. Therefore, most scholars advocate removing the broken catheter as soon as possible to reduce the risk of surgery and iatrogenic injury to the patient[9,10]. Due to the enhancement of patients' legal and self-protective awareness, it is often difficult to resolve medical disputes involving epidural catheter rupture, so it is necessary to remove the residual epidural catheter as soon as possible. Conventional surgery requires removal of the lamina

and possibly even some of the articular process, destroying stability of the spine. The surgical trauma is extensive, the bleeding is heavy, and the postoperative recovery is slow. Even auxiliary pedicle screw internal fixation may be required, which significantly increases the medical cost and leads to medical disputes. As a result, the anxiety of anesthesiologists has significantly increased, which has seriously affected their practice. Percutaneous spinal endoscopy is currently the standard technique for the treatment of degenerative diseases of the lumbar spine[11]. It is less invasive and costly, allows a quicker recovery, and does not destroy the stability of the spine[12]. It is an effective method for the treatment of epidural catheter rupture. In this study, 7 cases of epidural catheter rupture and partial retention were successfully treated using a percutaneous endoscopic technique to avoid the occurrence of medical disputes, and the technical operation and experience are discussed below.

2. Methods

2.1 General information:

Seven patients with epidural catheter rupture were treated at our hospital from October 2015 to October 2019; and the study protocol was approved by the Ethics Committee in The Second Affiliated Hospital of Zunyi Medical University. there were 3 males and 4 females, aged 45.43 ± 17.74 y (24 ~ 68 y). One case occurred at our hospital, and the remaining 6 cases were from different primary county hospitals. All patients underwent the operation at the local hospital. The anesthesiologist determined that the epidural catheter was broken and informed the patient and his or her family that the endoscopic technique was needed to remove the residual epidural catheter. The patient was transferred to our hospital for spinal endoscopy to remove the residual catheter. Before the patient was admitted to our hospital, the author fully communicated with the anesthesia operator to determine the puncture gap, the direction of catheter implantation, and the length of residual catheter. Before the operation, the lumbar spine was examined by X-ray and MRI and the lumbar puncture space was examined by CT to rule out lumbar spine lesions. The epidural space is located in the lumbar segment. There were 3 cases of cesarean section, 2 cases of lower extremity surgery, and 2 cases of pelvic surgery. Catheter rupture occurred during catheterization in 3 cases, during successful needle retraction in 3 cases and after extubation in 1 case.

2.2 Surgery:

In one case, the patient was treated immediately at our hospital. The patient underwent surgical anesthesia for bladder stone removal. The epidural catheter was ruptured during the catheterization process. Surgical anesthesia was replaced with general anesthesia. Then, the prone position of the patient was changed, and the puncture point was selected for endoscopic surgery according to the positioning point of the anesthesia operator, the direction of tube placement, and the length of the residual catheter. That is, the anesthesia puncture point was avoided, the head end of the catheter toward the center of the spinal canal was located, the endoscopic operating system was placed, and the remaining epidural catheter was completely removed. The remaining 6 patients underwent surgery under general anesthesia. After satisfactory general anesthesia with intubation was achieved, the patient was

placed prone on a fluoroscopic carbon fiber surgical bed, with hip flexion and knee flexion to achieve proper posterior lumbar protrusion. while considering the history of epidural puncture. X-ray was used to locate the puncture gap (Fig.1A) and mark the puncture point (Fig.1B). Conventional disinfection was performed, a sterile towel sheet was spread over the area, and a puncture guide needle was inserted at the marked point (Fig.1C). X-ray fluoroscopy was used to determine the correct position of the guide needle (Fig.1D); an expansion rod was implanted through the guide needle, and a working sleeve was placed (Fig.1E). Then, X-ray fluoroscopy was performed to ensure that the working sleeve was positioned correctly and that the depth was appropriate (Fig.1F-G). The endoscopic operating system was placed, and the operation was begun under continuous saline irrigation. The direction of the working cannula was adjusted to clearly reveal the epidural space and explore the left and right sides from the center to find the remaining epidural catheter (Fig.1H). The residual ruptured epidural catheter was removed (Fig.1I). Radiofrequency hemostasis was performed, the operating system and working sleeve were removed, one needle was used to suture the skin incision, the sterile dressing was covered, and the operation was ended.

2.3 Postoperative treatment

Eight hours after the operation, the patient was placed on supine rest; vital signs were monitored by electrocardiography, and lower limb sensory-motor function and active lower limb functional activities were observed. If permitted by the patient's other surgical conditions, he or she could wear a waist support to get out of bed and walk on the same day. According to individual adaptation, the amount of activity was gradually increased, and the patient returned to normal daily activities.

2.4 Observation indicators

- (1) Basic information: the patient's age, sex, anxiety score and surgical site before surgery; the age, experience, and anxiety score of the responsible anesthesiologist.
- (2) Intraoperative observations: the operation time, intraoperative blood loss, and intraoperative complications.
- (3) Postoperative observations: wound healing, neurological function, anxiety score, postoperative low back pain VAS score.

2.5 Statistical analysis

This study used SPSS 22.0 statistical software to process the collected data. The measurement data are presented as the mean $\pm$ standard deviation. Pre- and postoperative anxiety scores were compared by repeated measures analysis of variance. The significance level of the difference was set at $P < 0.05$.

3. Results

All 7 patients in this group underwent successful removal of the epidural catheter and didn't lead to medical disputes. It was confirmed by surgery that the tail end of the residual tube was located in the spinal canal; the operation time was 54.14 ± 14.45 (32–78) minutes, and the intraoperative blood loss was 9.134 ± 3.078 ml(5–15 ml). There were no cases of damage to the dura mater, cerebrospinal fluid leakage, sensory and dyskinesia of lower extremities, or bowel dysfunction. Regarding the time of surgery, in 1 case, the residual catheter was removed immediately after being broken, and in 6 cases, it was removed within 1 week after being broken.

The patients had no obvious low back pain after surgery, with VAS scores from 0 to 2. Stage I healing of the incision was observed, with no complications, such as infection of the incision. Before removal of the ruptured catheter, the patient had obvious anxiety. There were 5 cases of moderate anxiety and 2 case of severe anxiety. However, the postoperative patient anxiety score was significantly improved, as the patient was without anxiety. The age of the anesthesiologist involved was 27.0 ± 1.414 y (25 ~ 29 y), and the duration of experience in anesthesiology was 21.57 ± 6.754 (12 ~ 31) months; the anesthesiologists had mild and moderate anxiety before the catheter was removed. After the catheter was removed, the patient recovered smoothly, and anxiety symptoms disappeared (see Table 1).

Table 1

Anxiety scale ($\bar{x} \pm s, n = 7$)

	Sex (male)	Sex (female)	Age (y)	Preoperative SAS score	Postoperative SAS score	SAS score at 1 m postoperatively
Anesthesiologist	5	2	27.0 ± 1.414	58.0 ± 4.761	49.57 ± 1.512	46.0 ± 1.155
Patient	3	4	45.43 ± 17.74	61.29 ± 5.345	48.86 ± 3.132	45.86 ± 1.773

Note: SAS (Self-Rating Anxiety Scale); y: year; m: month.

4. Discussion:

Epidural catheter rupture is one of the complications of epidural block in clinical anesthesia. Its risk is accompanied by the implementation of clinical anesthesia. Most female patients have no obvious symptoms or signs in the early stage[1, 5, 13]. Epidural catheter materials are all biologically compatible materials that have been verified by clinical safety experiments. Generally, foreign materials, even biologically compatible materials, in the body can be recognized by the immune system. The long-term retention of foreign materials in the body will result in the formation of an immune complex or inflammatory granuloma around the foreign material[6, 14]. Those patients without clinical symptoms do not need special treatment and can be clinically observed. When the patient shows symptoms of nerve compression or irritation or a foreign body stress response, it is too late to consider surgical treatment, as

the difficulty and risk of surgery are significantly increased; thus, it is recommended to remove the residual catheter as soon as possible[7, 8]. Early routine surgery requires removal of the lamina, spinous processes, and articular processes of the corresponding segment to remove the broken catheter, which destroys the stability of the spine and requires the assistance of the pedicle screw rod system to maintain spinal stability[9, 15]. Therefore, conventional surgery is traumatic and expensive, involves heavy bleeding, and results in slow postoperative recovery and obvious pain in the operation area[14, 15]. These factors will inevitably lead to complaints from the patients and their families, who may resort to law and initiate a medical dispute[16]. Such events also obviously affect the daily work of anesthesiologists, leading to anxiety and frustration, which are not conducive to the growth and development of young anesthesiologists. Some large hospitals no longer even perform epidural anesthesia, and all operations are performed under general anesthesia, which not only prevents young doctors from gaining the basic operation skills of epidural puncture but also greatly increases medical costs and wastes medical resources.

In recent years, due to the wide application of spinal endoscopy technology and the rapid development of minimally invasive spinal surgery and medical imaging, the level of percutaneous minimally invasive endoscopy technology in the diagnosis and treatment of spinal diseases has improved significantly[17, 18]. From the cases in this study, it can be seen that the percutaneous, fully endoscopic technique can be used to safely remove the residual epidural catheter, with significantly reduced iatrogenic injury and medical expenses compared with conventional surgery, and can even avoid the potential resulting medical disputes. Epidural catheter rupture has a very low incidence and mostly occurs at primary hospitals. Our hospital admitted a total of 7 cases in 4 years from 7 different hospitals; accidents are more common among young people who have been employed for approximately 2 years as anesthesiologists. During communication with the patient before the operation, inform the patient that the dural catheter may rupture during the anesthesia operation but that even in this case, it can be removed by a percutaneous endoscopic technique, which has no obvious impact on the patient's recovery. Patients and their families can generally recognize and understand the risk. The SAS scores of the patients and operating doctors show that with successful removal of the residual catheter by endoscopic surgery, the patient's recovery was smooth, the SAS scores of both the patient and doctor significantly decreased, and a positive and healthy outlook was obtained. At present, the commonly used epidural catheters are difficult to identify on imaging, which leads to a lack of objective imaging data for surgical judgment. Although there are epidural catheters containing steel wires for clinical use, which can reduce the probability of epidural catheter rupture and increase the recognition of the epidural catheter on imaging after rupture, due to the high cost, they have not been popularized in clinical practice[19, 20]. In anesthesia by epidural block, a channel is created for the bolus injection of local anesthetics. It can also be used for lumbar cistern drainage in neurosurgery patients. Epidural catheters are even used during the infusion of cryoprecipitate and platelets into the amniotic cavity to treat premature rupture of fetal membrane and oligohydramnios in pregnant women[21, 22]. This approach provides a new perspective on the use of epidural catheters, prompting clinicians to understand the application and clinical value of epidural catheters and better use this clinical device[22, 23, 24].

Clinical anesthesia complications and anesthesia practice go hand in hand. How to minimize the risks and complications of anesthesia is an eternal topic of clinical anesthesia safety and quality control[1, 4, 7, 8]. According to the relevant literature and subjective experience, the following points merit attention: First, when it is difficult to place the epidural puncture catheter, care should be taken to remove the epidural catheter together with the puncture needle and avoid withdrawal of the tube first and then the needle. Second, it is recommended to use a reinforced epidural catheter when inserting a catheter for epidural block. Third, the catheter and the puncture needle arc should be kept close during puncture of the epidural space to minimize the possibility of the puncture cannula damaging the catheter during tube placement[25]. Fourth, when removing the epidural catheter at the end of the operation, the applied force should be moderate and stable, and the catheter should not be forcibly removed[26]. Fifth, when catheter removal is difficult, the patient should be assisted in returning to the puncture position for trial removal, and a deep vein puncture needle should be used to remove the epidural catheter if necessary[27]. Sixth, the operator should not panic if the epidural catheter ruptures and partially remains in the body; the family of the patient should be informed in a timely manner, and the spine endoscopist should be contacted for the removal operation, or the operator should wait for the patient to stabilize and then perform endoscopic surgery to remove the broken catheter[28]. Seventh, it is necessary to grasp the relevant knowledge and the process of the diagnosis and treatment of foreign bodies in the spinal canal to minimize the medical risks, iatrogenic injuries and risks for complications to ensure the safety and normal practice of clinical medicine.

The percutaneous endoscopic removal of a residual epidural catheter is of great clinical significance. The following points should be grasped when implementing the percutaneous spinal endoscopic technique: 1. Localization of residual tube: Accurate localization is the basis of a successful operation. A detailed understanding of the previous operation and the length of the residual tube is essential for judging the location of the broken end of the catheter in the body. 2. CT and MRI examination of the lumbar spine: When using an ordinary epidural catheter, the remaining catheter is difficult to identify and can only be determined according to the specific conditions of the anesthesiologist's operation. If an enhanced epidural catheter is used, CT and MRI examinations can allow identification of the residual catheter. 3. Positioning of the surgical path based on the clear puncture gap, direction of the catheter, and length of the residual tube. Correctly determining the location of the residual broken tube in the body and applying the correct method to locate the residual tube are keys to the success of the operation. As shown in this study, the percutaneous endoscopic technique causes minimal trauma, has a high success rate, and is easy for patients and their families to accept. It can relieve patients' worries, improve patients' physical and mental health, and help prevent medical disputes. The shortcomings of this study are the small number of cases and the lack of cases involving the thoracic spinal canal, long-term residual catheterization and granuloma formation around residual catheters. More clinical studies are needed.

5. Conclusion

Percutaneous spinal endoscopy is a safe and effective minimally invasive technique for removing residual epidural catheters. It causes less trauma and less bleeding, allows a faster recovery, and has a

low cost. It does not affect the recovery of patients from other surgical operations and reduces both medical risks and medical costs. At the same time, it avoids or reduces the occurrence of medical disputes and eliminates the pressure on young anesthesiologists regarding similar adverse events, and helps relieve young anesthesiologists' professional anxiety and promotes their active and healthy work.

Declarations

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Conflict of Interest: There is no conflict of interest.

Availability of data and materials

All data generated or analysed during this study are included in this article [and its supplementary information files].

Authors' contributions

Weijun Kong and Wenbo Liao contributed to the study design and writing of the manuscript. Guangru Cao and Qian Du performed the data collection and data analysis. Dexing Liu and Yiyong Wei edited the manuscript. All authors read and approved the final version of the manuscript.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Figures

Figure 1

Typical case: Female, 26 years old, cesarean section, lumbar 2-3 epidural space cephalic catheter rupture and residual epidural catheter. A-B, X-ray was used to locate the puncture gap and mark the puncture point; C, a puncture guide needle was inserted at the marked point; D, X-ray fluoroscopy was used to determine the correct position of the guide needle; E, a working sleeve was placed; F-G, X-ray fluoroscopy was performed to ensure that the working sleeve was positioned correctly and that the depth was

appropriate;H The residual epidural catheter was clearly visible under the endoscopic view; I, Remove the remaining epidural catheter completely.