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| Original Article |

Use of Imaging Agent to Determine Postoperative Indwelling Epidural Catheter Position

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Background:

Epidural anesthesia is widely used to provide pain relief, whether for surgical anesthesia, postoperative analgesia, treatment of chronic pain, or to facilitate painless childbirth. In many cases, however, the epidural catheter is inserted blindly and the indwelling catheter position is almost always uncertain.

Methods:

In this study, the loss-of-resistance technique was used and an imaging agent was injected through the indwelling epidural anesthesia catheter to confirm the position of its tip and examine the migration rate. Study subjects were patients scheduled to undergo surgery using general anesthesia combined with epidural anesthesia. Placement of the epidural catheter was confirmed postoperatively by injection of an imaging agent and X-ray imaging.

Results:

The indwelling epidural catheter was placed between upper thoracic vertebrae (n = 83; incorrect placement, n = 5), lower thoracic vertebrae (n = 123; incorrect placement, n = 5), and lower thoracic vertebra-lumbar vertebra (n = 46; incorrect placement, n = 7). In this study, a relatively high frequency of incorrectly placed epidural catheters using the loss-of-resistance technique was observed, and it was found that incorrect catheter placement resulted in inadequate analgesia during surgery.

Conclusions:

Although the loss-of-resistance technique is easy and convenient as a method for epidural catheter placement, it frequently results in inadequate placement of epidural catheters. Care should be taken when performing this procedure. (Korean J Pain 2010; 23: 247-253)

Key Words:

epidural anesthesia, iotrolan, pain, postoperative, radiography.

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INTRODUCTION

Because epidural anesthesia can be carried out relatively conveniently, it is widely used in clinical settings for surgical anesthesia, postoperative pain relief, and treatment of chronic pain. Epidural anesthesia is also effective for postoperative anesthesia and may improve the survival rate of surgical patients [1]. In addition, it is becoming clear that epidural anesthesia has multiple effects, including controlling a variety of stress reactions to surgery and reducing surgery-related complications [1-3].

The general method for locating the epidural cavity is the loss-of-resistance technique, which utilizes the fact that the epidural cavity is a vacuum. This procedure is performed blindly and relies on fingertip perception; however, in some cases loss-of-resistance is achieved in locations other than the epidural cavity. Therefore, it is possible to erroneously place the epidural catheter in the paravertebral space, prevertebral space, subarachnoid membrane, subdural membrane, or a blood vessel. Even if the epidural needle arrives at the epidural cavity as intended, the indwelling catheter will not necessarily be suitably positioned or under appropriate conditions. Furthermore, when the procedure is accurately carried out and the catheter is considered to have been successfully placed in the epidural cavity, doubts may still arise about the indwelling epidural catheter's position and condition such as inadequate anesthesia, pain relief in a larger area than anticipated, motor paralysis of the patient, or excessive change in hemodynamic stability.

Epidural imaging is widely used as a diagnostic tool for a variety of patients with vertebral conditions [4,5]. It is also used to confirm the position of the epidural catheter or epidural cavity itself, or to determine the spread of epidural anesthesia to the epidural cavity. As such, it is an effective confirmatory step for the safe clinical use of epidural anesthesia [6].

We hypothesized that it might be possible to easily confirm placement of the epidural catheter and the imaging scope by administering an imaging agent through the epidural catheter postoperatively and then taking X-rays of the thoracic or abdominal area.

MATERIALS AND METHODS

1. Subjects

The Institutional Review Board of the Faculty of Medicine at our university approved the study protocol, and both patients and controls provided informed consent. The study duration spanned a 9-month period from April 2007 to December 2007. Of all surgical, urological, and obstetric patients scheduled to undergo surgery using the combination of epidural anesthesia and general anesthesia, patients with a prior history of hypersensitivity to iodine or iodine imaging agents; patients with critical cardiac, hepatic, or renal impairments; and those with an American Society of Anesthesiologists (ASA) physical status classification of III or higher were excluded. Study objective were explained and consent obtained from the 268 patients who agreed to participate (Table 1).

2. Administration of epidural anesthesia

Before general anesthesia, 17 G × 80-mm Tuohy needles (Hakko Medical Co., Tokyo, Japan) were inserted in the lateral position during complete wakefulness and advanced to the epidural cavity by means of either 5 ml of air or physiological saline solution using the loss-of-resistance technique. After confirming there was no reverse flow of cerebrospinal fluid or blood, the epidural catheter (950 mm with a diameter of 1.0 mm, Hakko Medical Co., Tokyo, Japan) was advanced 3 to 5 cm. A test dose was then injected through the catheter (3 ml of 1% Xylocaine

Table 1. Case Classification

Operated region	Epidural catheter indwelling region	X-rayed region
Thoracic surgery (lungs, mediastinum, esophagus)	Upper thoracic vertebrae (T5-T10)	Thoracic area
Abdominal surgery (stomach, upper alimentary canal, pancreas, kidneys, vesica, abdominal aortic aneurysm)	Lower thoracic vertebrae (T9-T12)	Abdominal area
Pelvic interior surgery (gynecological surgery, prostate)	Lower thoracic vertebrae-lumbar area (T12 or lower)	Abdominal area (centered around the pelvis)

Cases were classified based on surgical site, epidural catheter placement location, and X-ray imaging site.

containing 0.01 mg/ml adrenaline, AstraZeneca PLC, London, UK) to confirm there were no problems.

3. Postoperative epidural imaging

Immediately prior to taking postoperative thoracic or abdominal X-rays to confirm the removal of medical devices and placement of drains, the patients were injected with 5 ml Iotrolan 240 (Bayer Pharmaceutical Co., Leverkusen, Germany) through the epidural catheter. For imaging, a medical X-ray tube assembly (UG—5ME—OITB; Hitachi Medical Co., Tokyo, Japan) was used for thoracic X-rays (90–96 kV, 2.0–3.2 mA) and abdominal X-rays (72–80 kV, 16–32 mA). Following development of the images, the site of imaging, parameters of the imaging agent that reached the vertebral body, position of the epidural catheter, and location of the epidural catheter tip (only the portion revealed) were confirmed and recorded.

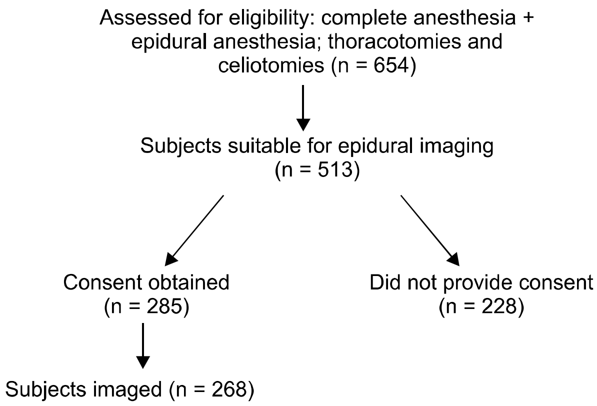

Fig. 1. Study flow. From a pool of 654 patients, we explained the objective of this study to 513 patients and obtained informed consent from 268 patients.

4. Determining the perioperative and postoperative effects of epidural anesthesia

During surgery, general anesthesia was induced and maintained with sevoflurane and intermittent administration of 1% mepivacaine (AstraZeneca PLC, London, UK) through the epidural catheter. The need for additional injections of mepivacaine was at the discretion of each anesthesiologist, as per usual clinical practice. Anesthesiologists who were not involved in epidural catheter placement recorded the degree of anesthesia. Effective cases were defined as those in which the anesthetic state was maintained perioperatively by the intake of 0.34 to 1.2 MAC sevoflurane combined with epidural anesthesia. Ineffective cases were defined as those that required an intake of more than 1.2 MAC sevoflurane or opioid administration. All other cases were designated as moderately effective.

5. Statistical analysis

Data were analyzed by two-factor repeated measures analysis of variance (ANOVA), as well as ANOVA followed by Scheffe's post-hoc test for multiple comparisons. A P value < 0.05 was considered statistically significant.

RESULTS

1. Findings from epidural imaging

Subject recruitment is outlined in Fig. 1. From a pool of 654 patients, study objectives were explained to 513 patients and informed consent was obtained from 268 of

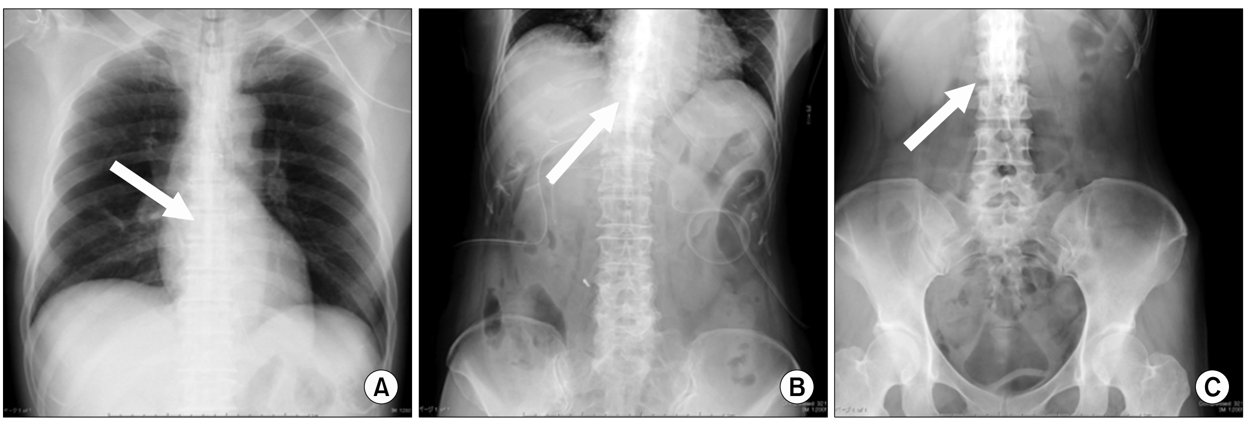

Fig. 2. Typical imaging views. Typical imaging views of the (A) upper thoracic area, (B) lower thoracic area, and (C) lumbar vertebrae. Arrows indicate regions imaged.

them. Fig. 2 presents what are considered typical findings of epidural imaging for thoracic surgery (Fig. 2A), upper abdominal surgery (Fig. 2B), and lower abdominal surgery (Fig. 2C). There were no cases that interfered with confirmation of postoperative gauze, foreign objects, or drain positioning. Often, the entire epidural imaging area was successfully targeted with plain X-rays following thoracic surgery. However, because of overlap with the cardiac silhouette, there were cases in which it was difficult to distinguish the imaging agent. Following abdominal surgery, it was relatively easy to confirm the imaging agent with plain X-rays, but spread of the imaging agent toward the subject's head could not be adequately confirmed with abdominal images only. In cases where epidural imaging was performed following lower abdominal surgery, 16 cases were excluded because the imaging agent could not be confirmed due to the epidural catheter insertion point being closer to the subject's head than the imaging area. Taking the above into consideration, cases were classified according to surgical site, epidural catheter placement location, and X-ray imaging site (Table 1).

2. Epidural catheter placement

Epidural catheter placement results determined by epidural imaging are presented in Table 2. In almost all cases, the epidural catheter was properly placed in the epidural space (234 cases). However, epidural catheter placement was inadequate in 17 cases (approximately 7%).

Among the 83 cases of thoracic surgery (upper thoracic vertebrae epidural catheter placement), five cases exhibited subcutaneous indwelling. One such case is shown in Fig. 3.

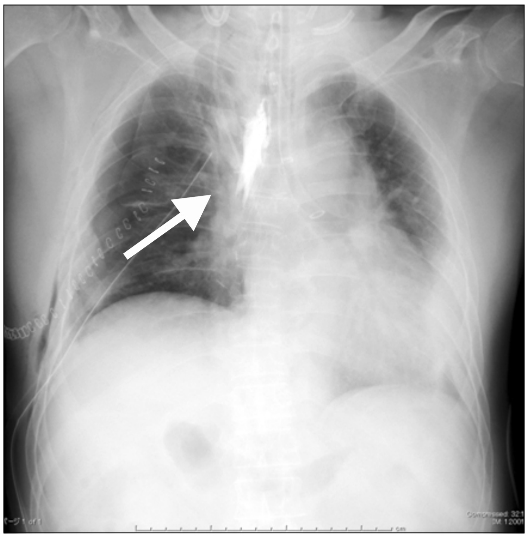

Fig. 3. Incorrect epidural catheter placement in the imaged upper thoracic area. Incorrect epidural catheter placement was observed by imaging of the upper thoracic vertebrae. Arrow indicates subcutaneous leakage of imaging agent.

Table 2. Differentiation of Imaged Findings by Region

	Epidural	Subcutaneous	Deviance from epidural cavity	Unclear	Total
Thoracic area	76	5	0	2	83
Abdominal area	119	3	2 (nerves)	1	123
Pelvic interior	39	0	7 (psoas compartment)	0	46

Epidural catheter placement results determined by epidural imaging.

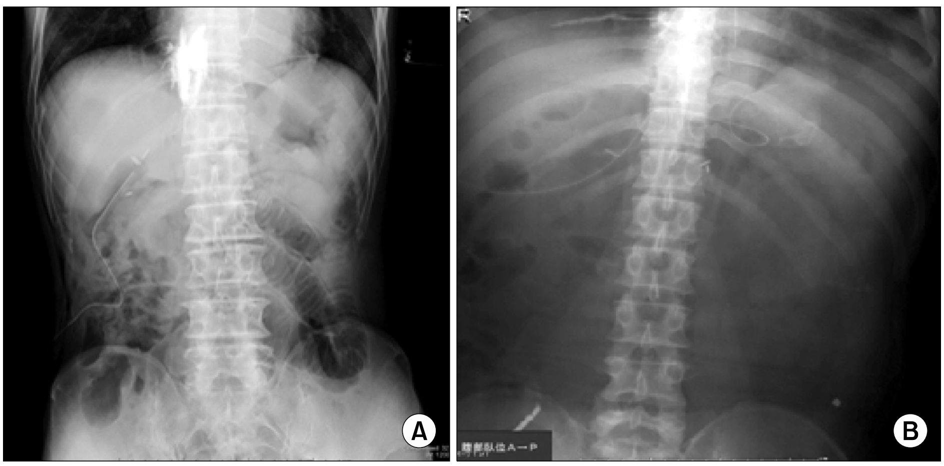

Fig. 4. Incorrect epidural catheter placement of the imaged lower thoracic area. Incorrect epidural catheter placement was observed by imaging of the lower thoracic vertebrae. (A) Administered imaging agent is leaking subcutaneously. (B) Administered imaging agent is highlighting the intercostal nerve.

Among the 123 cases of upper abdominal surgery (lower thoracic vertebrae epidural catheter placement), three cases exhibited subcutaneous leaking of the administered imaging agent, and two cases exhibited imaging agent leakage along the intercostal nerve following catheter deviance from the epidural cavity. Fig. 4A shows a case in which the imaging agent leaked subcutaneously, and Fig. 4B shows a case in which the imaging agent highlighted the intercostal nerve.

Among the 46 cases of lower abdominal surgery (lower thoracic vertebra-lumbar vertebra epidural catheter placement), seven cases exhibited imaging agent leakage into the psoas compartment. Fig. 5 shows a case in which the imaging agent leaked into the psoas compartment.

Fig. 5. Incorrect epidural catheter placement in the imaged lumbar area. Incorrect epidural catheter placement was observed by imaging of the lumbar area. Administered imaging agent is highlighting the psoas compartment.

3. Effects of surgery and findings from epidural imaging

Table 3 displays the relationship between postoperative anesthesia effects and epidural imaging findings. Even among cases determined to have effective or moderate anesthesia effects, there were three cases of imaging agent in the psoas compartment. In each case, the epidural cavity was simultaneously imaged; thus, it was not surprising to find analgesic effects. Among the 13 cases designated ineffective during surgery, most exhibited subcutaneous (n = 8) or psoas (n = 4) catheter placement; only one case among them definitively imaged the epidural cavity.

4. Epidural catheter insertion point and positioning of its tip

In 81 of the 268 cases (30.2%), the imaged insertion point corresponded well with the intended insertion point, while in 78 cases (29.1%), the insertion point did not correspond with the intended insertion point. In 109 cases (40.7%), the imaging agent and catheter overlapped, making it impossible to determine catheter tip location. Among those cases in which the anticipated insertion point and the actual insertion point differed by two or more vertebrae, many were inserted at the thoracic vertebra level; the maximum discrepancy was three vertebrae. Due to interference from the imaging agent, catheter tip position could not be clearly determined.

DISCUSSION

Epidural imaging involves injecting an imaging agent into the epidural cavity. It is a relatively safe procedure and is currently used to confirm locations of indwelling epidural catheters or to determine spread to the epidural cavity [6]. In this study, we were able to demonstrate this procedure's utility in evaluating positional irregularities. It is not currently standard practice to conduct epidural imaging

Table 3. The Effect of Epidural Anesthesia and Findings From Epidural Imaging

Effect	Epidural	Subcutaneous	Psoas compartment	Total
Effective	203	0	1	204
Moderately effective	49	0	2	51
Not effective	1	8	4	13

Relationship between effects of epidural anesthesia during surgery and imaged findings. "Not effective" status was not obtained unless there was constant intake of at least 1.2 MAC sevoflurane or opioid administration. "Effective" status was maintained perioperatively solely through intake of 0.34 to 1.2 MAC sevoflurane and administration of local anesthesia from an epidural catheter. All other cases were designated as "Moderately effective".

perioperatively. This is likely due to the extra time, labor, and costs involved.

In this study, we used thoracic and abdominal X-rays taken to determine the postoperative presence of accidentally retained gauze, surgical implements or indwelling drain location; we conducted our study in conjunction with such imaging. We also demonstrated that the imaging technique is adequate for epidural imaging (99%). By simply administering the epidural imaging agent, it is possible to confirm the location of epidural anesthesia, thereby reducing time, labor, and costs. Thus, the best time to carry out this confirmatory procedure may be postoperatively.

Over the course of inducing and maintaining epidural anesthesia, deviance from the vertebral body or ectopic migration occurred in approximately 3% of cases. This rate is slightly lower than that reported by Sánchez et al. or Hogan [7,8]. There was no significant difference in deviance according to catheter insertion approaches (median or paramedian), and we believe this to be a result of using relatively soft Hakko tubes. When we examined deviant cases, they occurred significantly more often with 5 cm insertion into the epidural cavity (5/7 cases); thus, it is possible that the incidence of epidural cavity deviance could be reduced by inserting the catheter only 3 to 5 cm.

The technique of using an indwelling epidural catheter to administer local anesthesia is currently in widespread clinical use to treat chronic pain and for pain relief purposes peri- and postoperatively. Reports have been published on its effects and efficacy [3-5,9]. In the clinical setting, anesthesia is sometimes inadequate despite an indwelling epidural tube. Our study demonstrated both the relatively high rate of possible deviance from the intended placement and how an improper placement yields poor efficacy of epidural anesthesia during surgery. Indeed, our epidural imaging identified many cases of inadequate epidural catheter placement. In these cases, epidural anesthesia efficacy during surgery was reported as insufficient. In contrast, previous studies have been conducted on the imaging area and analgesic effects of epidural anesthesia, as well as the correlation between them [10]. We observed relatively favorable peri- and postoperative analgesic effects in a broad range of cases. However, inadequate epidural catheter placement did not induce effective peri- and postoperative analgesia, consistent with results from previous studies. Our findings indicate that epidural imaging is useful for examining parameters of analgesic effect. Moreover, we argue that epidural imaging is necessary to perform accurate epidural anesthesia, because epidural anesthesia is used to treat peri- and postoperative pain. In the event that positional or other irregularities are observed, the procedure may need to be repeated. Thus, we believe that postoperative epidural imaging could evaluate whether epidural anesthesia was used safely and effectively.

Prior to the present study, we thoroughly questioned our subjects on their medical history, and limited the use of epidural imaging agent to the minimal 5 ml. As reported by Du Pen et al. [10] and Yokoyama et al. [11], administering 5 ml is sufficient, and we concur that 5 ml should be considered the standard amount of epidural imaging agent for administration. Although previous studies have reported side effects, such as sudden allergic reactions and renal impairment, during the course of conducting epidural imaging, we did not observe serious side effects [12,13]. Another study examined whether lateral dominance occurs as a result of increasing the amount of agent injected and reported on the utility of examining further spreading [14]. The results of the present study suggest that it is vital to conduct detailed history-taking on allergies and to avoid administration of excessive amounts of imaging agents to prevent side effects.

This study has several limitations. First, we did not examine the effective parameters of local anesthetics administration prior to carrying out general anesthesia, and we failed to clarify the direct relationship between the region affected by anesthesia and the epidural imaging region. In addition, it was difficult in some cases to determine the precise catheter location because the catheter deviated from the region being X-rayed. Because only frontal images were taken, migration into the epidural cavity was difficult to determine [15,16]. It is also possible that bias existed when patients' pain levels were determined because local anesthesia was administered perioperatively according to the judgment of anesthesiologists. We did not examine long-term postoperative analgesic effects. From the above, we believe that further research is necessary in order to clarify the relationship between items we did not investigate in this study and epidural imaging findings that emerge in future incidents during epidural anesthesia.

In summary, our study demonstrated that injection of an imaging agent from the epidural catheter for epidural imaging allows for convenient identification of positional irregularities following epidural anesthesia and further revealed its utility for determining the effects of epidural anesthesia. As well, we demonstrated that epidural catheters inserted blindly have a relatively high rate of migrating away from the intended placement site. To conduct epidural anesthesia with greater safety in the future, routine epidural imaging should be performed to confirm positional and other irregularities.

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