Korean J Pain Vol. 22, No. 2, 2009 대한통증학회지 2009; 22: 124-129
DOI : 10.3344/kjp.2009.22.2.124 □ 원 저 □

경막외 카테터의 적합한 위치지표로서의 주입공기의 흡인

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정순호 · 박대식* · 문성호 · 조광래 · 이상은 · 김영환
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The Aspiration of Injected Air via an Epidural Catheter as an Indicator for Appropriate Placement of the Catheter in the Epidural Space

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Background: The "gold standard" for proper epidural catheter positioning is a clinical response, as assessed by a pinprick test. Yet it may take time or it may be difficult to perform this test after epidural catheter placement in sedated or uncooperative patients or during general anesthesia. We assessed the usefulness of aspirating injected air via an epidural catheter as an indicator of correct epidural catheter placement.

Methods: We surveyed 200 patients who underwent surgery under general or epidural anesthesia. A Tuohy needle was inserted into the epidural space with using the hanging drop technique. After placement of the epidural catheter, 3 ml of air was injected via the catheter, and then the volume of aspirated air was measured.

Results: The mean volume of aspirated air was 2.3 ± 0.7 ml (75% of the injected air volume) and this ranged from 0 to 3 ml.

Conclusions: Aspiration of injected air is a simple alternative method for identifying the appropriate placement of epidural catheters in the epidural space. **(Korean J Pain 2009; 22: 124-129)**

Key Words: air aspiration, epidural anesthesia, epidural catheter.

INTRODUCTION

After inserting an epidural catheter insertion, the anesthesiologist has to confirm that the catheter is appropriately placed in the epidural space, but this can be challenging even for experienced anesthesiologists. Appropriate localization of epidural catheters by epidural nerve stimulation[1,2] and assessing the epidural pressure waveform[3] have been described, and ultrasound imaging[4,5] has been used for guiding the insertion of an epidural catheter. The “gold standard” for proper epidural catheter positioning is the clinical response, as assessed by a pinprick test for recognition of the epidural blockade. Yet this test may take time or it may be difficult to perform in sedated or uncooperative patients, or during general anesthesia. Moreover, the administration of a test dose of local anesthetic and epinephrine via the epidural catheter to detect intra-

접수일 : 2009년 3월 23일, 1차 수정일 : 2009년 4월 2일
승인일 : 2009년 4월 14일
책임저자 : 정순호, (614-735) 부산시 부산진구 개금동 633-165
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본 논문은 2008년도 인제대학교 학술연구조성비 보조에 의한 것임.

Received March 23, 2009, Revised April 2, 2009
Accepted April 14, 2009
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This work was supported by Grant from Inje University, 2008.

vascular injection may be unreliable in elderly patients,[6] pregnant woman,[7] patients taking beta blocking agents, or during general anesthesia.[8]

We hypothesized that if an epidural catheter has been sited appropriately in the epidural space after insertion, then air injected via the catheter would remain in the area surrounding the catheter tip and this air would not move out of the epidural space into the intervertebral foramen or the intravascular or subarachnoid space immediately after injection. We could then aspirate some of the injected air immediately after its injection to confirm the appropriate placement of the epidural catheter or rule out an intravascular or subarachnoid injection. So, we measured the volume of aspirated air immediately after injecting the air and we evaluated the relationship between the volume of aspirated air and the success or failure of epidural blockade.

MATERIALS AND METHODS

The study protocol was approved by the Institutional Review Board of our hospital, and we obtained written informed consent from each patient. The patients were included in the study if they were 30 to 65 years old and they had no contraindications to epidural catheter placement, including coagulopathy, systemic infections, or infections at the site of the planned epidural. After entering the operating room, all the patients were monitored with electrocardiography, pulse oximeter, and a blood pressure cuff. The patients were appropriately assigned to one of 4 groups of epidural catheter insertion: T5－8 (group 1), T8－11 (group 2), T11－L2 (group 3) and L2－5 (group 4) based on the site of surgery. With the patient placed in the lateral position, an 18 G Tuohy needle was inserted into the epidural space by using the hanging drop technique with saline. The choice of the method of anesthesia (general or epidural) and the approach to the epidural space (median or paramedian) was left to the discretion of the attending anesthesiologist. A 20 G epidural closed end nylon catheter (BD Perisafe™, BD Medical System, Belgium), with a blunt closed-end tip design and 3 sideports in the distal 1 cm, was advanced 3 cm into the epidural space. After confirming that no blood or cerebrospinal fluid had been aspirated via the epidural catheter, the anesthesiologist injected 3 ml of air with using a 3 ml plastic syringe. Without disconnecting the syringe from the hub of the epidural catheter, the anesthesiologist slowly aspirated the injected air and the volume of aspirated air was measured. If the aspirated air was less than 2 ml, then we traced the air using transthoracic echocardiography to detect if a venous air embolism had occurred.

We excluded those patients who displayed aspirated blood or cerebrospinal fluid during aspiration via the epidural catheter. After measuring the pirated air, we administered a test dose of local anesthetic with epinephrine via the epidural catheter to ascertain if improper placement of the catheter had occurred.

For the patient assigned to receive epidural anesthesia, the local anesthetic for epidural anesthesia was administered via the epidural catheter. If proper epidural block was achieved, as assessed by a pinprick test and, without the signs or symptoms of intravascular or subarachnoid injection, then we concluded that the epidural anesthesia was successful. For the patients assigned to receive general anesthesia, the drugs for postoperative pain control following general anesthesia were administered via the epidural catheter as a single dose of fentanyl 50－100 μg, and this was followed by infusion of fentanyl 25－100 μg/hr with 0.0625% bupivacaine,[9] with no other analgesic drug, beginning at about 30 min before the end of the operation. After recovery from general anesthesia and the recovery of the patient's verbal communication, the VAS (visual analog scale) score was measured in the recovery room; scores lower than 30 mm were regarded as successes and scores higher than 70 mm were regarded as failures. If a VAS score was between 30 and 70 mm, then the patient was administered a single, age-defined dose of fentanyl with 1% lidocaine via the epidural catheter, and the VAS score was rechecked 10 minutes after this drug administration. If the rechecked VAS score was higher than 30 mm, then we concluded that the postoperative pain control had failed. The patient was monitored until 30 minutes after VAS measurement and then the patient was sent to the recovery ward. We monitored the vital signs and the clinical signs and symptoms during recovery to detect complications such as dural puncture headache, pneumocephalus, and the inadvertent injection of local

anesthetics into a vessel or the subarachnoid space. One anesthesiologist was responsible for epidural catheter insertion to the time of and including air aspiration, a second anesthesiologist administered local anesthetics or analgesics, and a third anesthesiologist decided whether the epidural anesthesia and postoperative pain control were successful.

1. Statistics

The data is expressed as mean values ± SDs and it was statistically analyzed by one-way analysis of variance to compare the volume of aspirated air between the groups. Statistical analysis was performed using MedCalc for Windows, version 10.0 (MedCalc Software, Mariakerke, Belgium). The significance of the nonparametric data (e.g., sensitivity, specificity) was determined by performing ROC (Receiver Operating Characteristic) curve analysis. The criterion or cut-off value of the volume of aspirated air was selected so that the highest sensitivity and specificity for successful epidural anesthesia was achieved. For all comparisons, P values < 0.05 were considered significant.

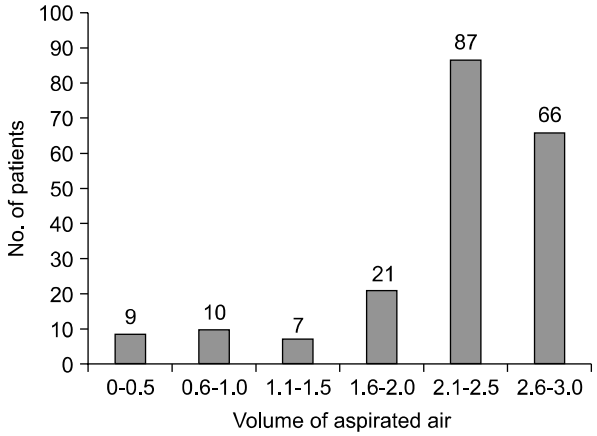

Fig. 1. Patient distribution for the aspiration volume. The mean volume of aspirated air was 2.3 ± 0.7 ml (75% of the injected air volume) and this ranged in individual patients from 0 to 3 ml.

RESULTS

The mean volume of aspirated air was 2.3 ± 0.7 ml (75% of the injected air volume) and this ranged in individual patients from 0 to 3 ml (Fig. 1). Since the differences between the groups were not significant (Table 1), we did not determine the relationship between the volume of aspirated air and the patients' gender, age, weight or height. The highest sensitivity (78.0%) and specificity (100%) for successful epidural anesthesia was achieved at 2.0 ml of aspirated air (67% of the injected air volume). The highest sensitivity (98.8%) and specificity (100%) for successful postoperative pain control following general anesthesia was achieved with 0 ml of aspirated air. All of the patients (87 patients) with more than 2.1 ml aspirated air and 14 patients with less than 2.1 ml aspirated air had successful epidural anesthesia, with success in all the patients for controlling their postoperative pain, except 2 patients who had no air aspirated. The volumes of aspirated air were less than 2.1 ml in 4 patients with failed epidural anesthesia, and no air was aspirated in 2 patients with failed postoperative pain control following general anesthesia (Fig. 2).

Table 1. Patients' Characteristics

Group	Age (years)	Anesthesia (G/E)	Site of operation	Volume of aspirated air (ml)
1	56 ± 9	50/0	Chest (18/4) Hepatobiliary (7/3) UGI (10/8)	2.1 ± 0.8
2	57 ± 12	45/5	Colon (29/9) Uro. (12/0)	2.3 ± 0.7
3	45 ± 10	0/50	Gyn. (0/41) Low. ext. (7/2)	2.3 ± 0.6
4	54 ± 11	0/50	Gyn. (0/4) Low. ext. (11/35)	2.4 ± 0.6

Values are means ± SDs or the number of patients, G: general anesthesia, E: epidural anesthesia, UGI: upper gastrointestinal tract surgery, Uro: urologic surgery, Gyn: gynecologic surgery, Low ext: lower extremity surgery.

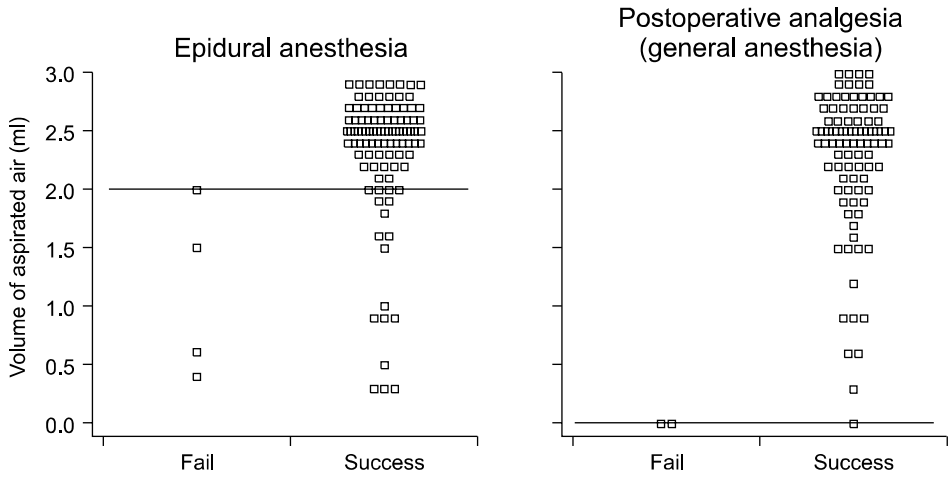

Fig. 2. Interactive dot diagram. The highest sensitivity (82.2%) and specificity (100%) for successful epidural anesthesia were achieved at 2.0 ml of aspirated air (horizontal black line in the left box). The highest sensitivity (98.8%) and specificity (100%) for successful postoperative pain control were achieved at no aspirated air (horizontal black line in the right box). Success or Fail: success or failure of anesthesia or postoperative pain control.

DISCUSSION

Epidural anesthesia failed in 4 patients, with no or incomplete blockage in one patient each and unilateral blockage in two patients; these patients had 0.4, 0.6, 1.5 and 2.0 ml of aspirated air, respectively. In addition, postoperative pain control failed in two patients, with both of them having 0 ml of aspirated air. The volume of aspirated air varied from 0 to 3 ml in the individual patients. These results raise two questions. The first is how to explain the inability to aspirate the entire volume of injected air or the variability of the aspirated air volume. The second question is how to document that the volume of aspirated air was related to the success or failure of epidural anesthesia or postoperative pain control. The catheter tip is usually inserted lateral to the dura in the intervertebral foramen, with a far lateral catheter position being a more common cause of asymmetric block than any anatomic barriers to the spreading solution.[10] In our study, the failure of epidural anesthesia may have been due to an inappropriate catheter tip location. Radiographically, the catheter tip should be located in the epidurovascular, epidurosubdural or epiduro intrathecal space, while a proximally placed catheter tip port simultaneously retains normal access to the epidural space.[11,12] Our study used a three-port catheter and air was injected at a threshold speed of, 2－4 ml/s to distribute air through all three catheter ports,[13] which caused variations in the volume of aspirated air. Some volume of the injected air could be dispersed widely in the epidural space or it could escape from the epidural space through the intervertebral foramen, depending on the catheter tip location. In rare cases, a partial volume of the injected air might be injected into the intravascular, subdural or intrathecal space, leading to incomplete aspiration.

Small physical spaces, such as intramuscular spaces beyond the interspinal ligament or subcutaneous space, would also allow better aspiration than an epidural space. However, experienced anesthesiologists can identify these placements by the resistance or kinking of the catheter during insertion. We could not perform accurate pressure measurements during air injection or withdraw. The injection and withdrawal were done by one person and the piston of the syringe was released after withdraw so as to not expand the aspirated air. The highest sensitivity and specificity for successful epidural anesthesia occurred at 2 ml of aspirated air, but the volume of aspirated air was lower for postoperative pain control (0 ml) (Fig. 2). Some patients with failed epidural anesthesia may have had good postoperative pain control because epidural analgesia with opioids does not require accurate placement of the catheter. Therefore, the success rate depends on whether the purpose is anesthesia or analgesia. The false-positives in this study occurred with anesthesia failure despite large (> 2 ml) volumes of aspirated air because the catheter tip location is not the only factor that influences the success of anesthesia. Epidural blockade can also fail due to an insufficient dose of drug, a non-uniform distribution of the injected drug or for other reasons. However, appropriate

placement of the epidural catheter is still required for success, and the clinical responses are the only method for verifying appropriate placement. To avoid an intravascular injection of large amounts of local anesthetics, an epidural test dose with epinephrine is used in most patients. However, the hemodynamic criteria of a positive intravascular injection of the epinephrine test dose may be unreliable for patients under general anesthesia, and the efficacy of the test dose may vary for different anesthetics.[14-16] Moreover, arrhythmia and myocardial ischemia can occur in elderly patients who are administered a test dose that contains small amounts of epinephrine.[17] In addition, subarachnoid block due to inadvertent subarachnoid injection of the test dose may not be detected in the patients who are under general anesthesia because of the inability to check for paresthesia or pain. Injection of air into the epidural catheter may cause pneumocephalus or venous air embolism when the ports of the catheter are located in the subarachnoid or intravascular space. Most of the reported cases of pneumocephalus occurred when performing epidural block with using the loss of resistance technique with air filled syringes, but fortunately this provoked only headaches and these headaches resolved without further sequelae, with iatrogenic pneumocephalus being uncommon.[18] We could not determine a minimum safe volume of air injected accidentally into the subarachnoid or intravascular space. The reported volume of air that provoked symptoms of venous air embolism varied from 0.07/kg to 0.4/kg,[19] but these patients had only slight symptoms or they resolve without sequelae. In our study, the volume of air that wasn't aspirated was about 0.8 ± 0.7 ml, and we could not trace the course of absorption of this air or detect air embolism on the transthoracic echocardiography. Yet none of our patients had symptoms of pneumocephalus or air embolism.

Thus, the volume of air aspirated after injection may indicate an appropriate catheter placement in the epidural space, and this is similar to the use of bispectral index monitoring as a surrogate endpoint for consciousness after using sedative drugs. When using a test dose of local anesthetic containing epinephrine is unreliable or it may cause cardiac problems (e.g., in patients under general anesthesia or pregnant women, or in patients with myocardial ischemia), aspiration of injected air may be a simple alternative for identifying the proper placement of the epidural catheter.

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