北海道脳神経疾患研究所医誌第21巻　2010. 12. P55～58

# Continuation Measurement of Thoracic Epidural Pressure

Satoshi OMORI, M.D., Shingo FURUSE, M.D.

Department of Anesthesiology, Nakamura Memorial Hospital and Hokkaido Brain Research Foundation, Sapporo, Japan

Abstract:

[Purpose] The aim of this study was to examine whether the epidural pressure can be measured for a long period of time using the continuation epidural infusion via the thorax.
[Materials and Methods] Ten adult patients undergoing surgery had an epidural catheter inserted via the thoracic interspaced. After induction of general anesthesia, continuous infusion of local anesthetic (0.2% ropivacaine) at a rate of 6 mL/h was applied epidural space. A pressure transducer was connected to the epidural catheter and the epidural pressure was measured. During surgery, changes in the epidural pressure were monitored at 0, 5, and 10 cm$H_20$ of positive end-expiratory pressure (PEEP). On postoperative day 1, and 2, the epidural pressure was measured in the supine position, the Queckenstedt test, and the 30º head-up position.
[Results] The epidural pressure was measured continuously and stably during surgery and until postoperative day 2, it increased significantly at 5 and 10 cm $H_20$ PEEP, and increased and decreased significantly in the Queckenstedt test and the head-up position, respectively.
[Conclusion] Continuous epidural infusion at a rate of 6 mL/h via the thorax allows stable measurement of the epidural pressure over a long period of time.

## INTRODUCTION

Epidural pressure is measured commonly by injecting a small volume of saline as a single injection into the epidural space through an epidural catheter connected to a pressure transducer[1,2]. Because the epidural space is a non-fluid-filled environment, this traditional method dose not allow for long-term, stable, and continuation of measurement of the epidural pressure[3]. To allows stable measurement of the epidural pressure, Iwama et al suggested that the single injection of saline should be changed to a continuous infusion at relatively high flow rate[3]. According to this concept, we examined whether the epidural pressure measured via the T10-T12 levels thorax can be measured stably for a long period of time.

## PATIENTS AND METHODS

Ten adults patients classified as ASA 1-2 undergoing surgery who provided informed consent were enrolled in this study. The Institutional Committee approved this study.

All patients received cephalic insertion of an 18-gauge multi-orifice epidural catheter (PERIFIX. B-BRAUN. Tokyo, Japan) via the thoracic interspaced between the T10-T11 and the T11-T12 levels. Subsequently, anesthesia was induced with propofol, oxygen, and sevoflurane, and laryngeal mask insertion was facilitated vecuronium. The anesthesia was maintained with oxygen and sevoflurane with mechanical ventilation of 8 to 12 mL/kg tidal volume, respiratory rate of 10 bpm. After induction and several minutes before the start of surgery, 6±1 mL of 0.75% ropivacaine was injected epidural space. And a continuous epidural infusion of 0.2% ropivacaine at a rate of 6 mL/h was initiated using a disposable portable pump connected to the epidural catheter by a 3-way stopcock. A pressure transducer available for monitoring arterial pressure (Life Kit: Ohmeda, Singapore) was then connected to the side pore of this stopcock and placed on the posterior axillary's line, and the epidural pressure was measured continuously in the supine position. About 5±1 mL of 0.75% ropivacaine was injected epidural space at 60-minutes interval until completion of surgery. The continuous epidural infusion was continued until postoperative day 2 for postoperative pain relief.

In the supine position and 15 minutes after the second epidural injection of 0.75% ropivacaine, the PEEP level was increased from 0 to 5 cm $H_20$ using a threshold resistance expiratory pressure valve. Ten minutes later, this level was increased to 10 cm $H_20$, followed up 10 minutes later by returning to 0 cm $H_20$. The mean epidural pressure level was recorded before the application of PEEP, and 10 minutes after application of 5 and 10 cm $H_20$ PEEP.

After complication of surgery, the laryngeal mask was removed from patients, who subsequently entered the intensive care unit. The epidural pressure measurement system and the continuous epidural infusion system were maintained until postoperative day 2. The pressure transducer was placed on the lateral upper abdomen where the midaxillary's line crossed the horizontal line of the ensiform process. On postoperative day 1, and 2, the epidural pressure was recorded with patient in the position, receiving jugular venous compression (Queckenstedt test), and a 30° head-up position. After these measurements, the epidural catheter was removed.

Changes in epidural pressure levels during analyzed by repeated measure one-way analysis of variance, followed up by Fisher's protected least significant difference for multi-comparison. Change in epidural pressure levels in the supine position. Queckenstedt test, and head-up position were analyzed by $t$ test. $P < 0.05$ was considered significant.

## RESULTS

The age, height, and weight of the patients was 58±10 years, 156±12 cm, and 52±9 kg, respectively, expressed as mean ± SD. Six patients were women and four patients were men. The position of insertion of the epidural catheter was T10-T11 in 4 patients, T11-T12 in 6 patients.

During surgery, the epidural pressure was successfully monitored continuously except for the time when the intermittent epidural injection was performed. Changes in the epidural pressure levels during the application of PEEP are shown in Table 1. The epidural pressure was increased significantly at 5 cm $H_20$ PEEP, and further increased at 10 cm $H_20$ PEEP.

After surgery, postoperative analgesia was clinically satisfactory in all patients, and the epidural pressure was successfully monitored continuously until postoperative day 2. The time course of the epidural pressure is shown in Table 2. The epidural pressure did not change significantly during this period when the patient was in the supine position. During the Queckenstedt test, the epidural pressure was increased significantly on each measurement day. After the patient was positioned 30° head up, the epidural pressure was decreased significantly on each measurement day. The record of epidural pressure waves in the supine position, Queckenstedt test, and head-up position is shown in Fig. 1.

Changes in Epidural Pressure During Application of PEEP

| | PEEP ($cmH_20$) | | |
|---|---|---|---|
| | 0 | 5 | 10 |
| Epidural Pressure (mmHg) | 12.1±3.9 (8-20)* | 17.3±3.3 (14-24) | 21.8±3.8 (18-28)* |

Values are mean ± SD (range)
*P < 0.05 vs 5 cm $H_20$ PEEP value.

Table 1 Changes in epidural pressure during application of PEEP

Time Course of Epidural Pressure After Surgery and Its Changes During the Queckenstedt Test or the Head-Up Position

| | Postoperative Day | |
|---|---|---|
| | 1 | 2 |
| Epidural Pressure (mmHg) | | |
| Supine position | 8.7±1.4 (6-11) | 8.8±1.3 (7-11) |
| Queckenstedt test | 17.4±2.3 (13-20)* | 17.8±2.3 (14-20)* |
| Head-up position | 4.5±0.7 (3-5)* | 4.5±0.8 (3-8)* |

Values are mean ± SD (range)
*P < 0.05 vs each supine position value

Table 2 Time course of epidural pressure after surgery and its changes during the Queckenstedt test or the head-up position

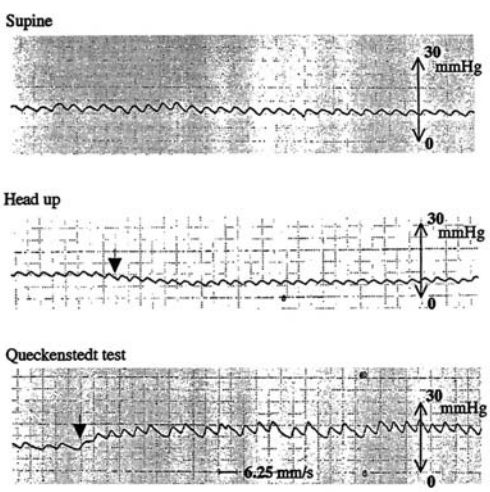


Fig. 1 Measurement of Epidural pressure during the supine position, Queckenstedt, and 30° head-up position.

## DISCUSSION

This study shown that injection of a fluid volume into the thoracic epidural space at about 6 mL/h allows stable monitoring of the epidural pressure up to 2 days. This result suggests that the epidural space becomes a fluid-filled environment, so that the intraspinal pressure may be easily transmitted to the epidural space. Intracranial pressure (ICP) is known to increase during the application of PEEP, which should result in an augmentation of the intraspinal pressure, except in the conditions with a blockage of the spinal canal. Furthermore, the ICP is increased and decreased during the Queckenstedt test and in the head-up position, respectively. To test whether the epidural pressure obtained in this study reflected the ICP, we examined changes in the epidural pressure during these procedures and the results were consistent with the known responses in ICP described earlier. In fact, there has been some report suggesting a correlation between the epidural pressure and ICP[1-3,5]. We have also measured both types of pressure simultaneously in 2 patients and documented similar records[3].

Measurement of ICP involves the measurement of intraventricular pressure, brain tissue pressure, subarachnoid pressure, and intracranial epidural pressure. Clinically, intraventricular pressure has been often used for ICP measurement, and, recently, a catheter with a pressure transducer attached at the tip has been developed, which commonly measures subarachnoid pressure. All of these methods require a burr hole open at the skull, which may have more invasion than measurement of the epidural pressure requiring epidural placement of the catheter. The primary use of ICP monitoring is in management of

intracranial hypertension; however, the question as to which pressure indicates the ICP has not been answered, and significant differences in pressure between various measurement sites are observed[6]. Another method, measurement of lumbar spinal pressure by subarachnoid catheterization, has been reported[2] in which cerebrospinal fluid drainage as a therapeutic maneuver is often combined. In this method, communication between the cranial and spinal subarachnoid spaces is necessary, but may be occluded depending on the severity of intracranial hypertension. Because the epidural pressure by our methodology seems to be identical to the intraspinal pressure, this limitation should be considered. Moreover, because a large volume of epidural injection causes ICP to increase significantly, epidural infusion at a relatively high flow rate may also be contraindicated in patients with severe intracranial hypertension. Taking these implications into consideration, an application of the epidural pressure as a possible indicator for estimation of the intracranial pressure should be limited to patients with mild to moderate intracranial hypertension, possibly to detect early onset of brain swelling or to determine the need for conventional ICP monitoring.

In this study, the pressure transducer was placed on the posterior axillary's line during surgery, and was placed on the midaxillary's line after surgery. This difference could be the cause of the difference in the epidural pressure values obtained during surgery and after surgery. We believe that the pressure transducer should be placed at the same height as the epidural catheter tip because the pressure at the catheter tip site is the most accurate indicator of epidural pressure. However, it is relatively difficult to determine this site. Because the patient moves appropriately after surgery, we recommend that transducer be placed on the lateral side of the upper abdomen when the epidural pressure is measured via the thoracic epidural catheter. Although an optimal spine level to monitor the epidural pressure is unknown, successful recording of the epidural pressure has been reported via the cervix or lumbus[2,3]. In this study, there was no apparent difference in epidural pressure with epidural location from T11-T12 to T10-T11. This suggests that measurement at any epidural level in the spine may provide satisfactory monitoring of the epidural pressure. Because the T10-T12 thorax is an easy site for epidural catheterization even in critically ill patients, we believe that the T10-T12 thoracic epidural space is one of the suitable sites for measurement of epidural pressure.

In conclusion, continuous fluid infusion at a rate of 6 mL/h into the thoracic epidural space allows stable monitoring of the epidural pressure for up to 2 days. The epidural pressure values appear sensitive to clinical maneuvers known to ICP. Monitoring of the epidural pressure may have use as a less invasive early detector of intracranial hypertension than conventional ICP monitoring.

## REFERENCES


1) Shah JL: Influence of cerebrospinal fluid on epidural pressure. Anaesthesia, 1981; 36: 627-631.
2) Mimura M, Kumeta Y, Echizenya K: Spinal epidural pressure as a less-invasive monitoring of intracranial pressure, Report of two cases of encephalitis. Journal of Anesthesia, 1997; 11: 237-238.
3) Iwama H: Simultaneous record of epidural and intracranial pressure. Acta Anaesthesiol Scand, 1997; 41: 800.
4) Shah JL: Positive lumbar extradural space pressure. Br J Anaesth, 1994; 73: 309-314.
5) Hilt H, Gramm HJ, Link J: Changes in intracranial pressure associated with extradural anaesthesia. Br J Anaesth, 1986; 58: 676-680.
6) Kosteljanetz M, Borgesen SE, Stjernolm P, et al: Clinical evaluation of a simple epidral pressure sensor. Acta Neurochir (Wien), 1986; 83: 108-111.