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Original Contribution

Bevel direction of epidural needles reliably predicts direction of catheter placement and contrast spread in human cadavers: results of a pilot study☆

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Abstract
Study Objective: To confirm the relationship between bevel orientation, catheter direction, and radiopaque contrast spread in the lumbar region.
Design: Pilot cadaver study.
Setting: Anatomy laboratory of a university hospital.
Measurements: Cadavers were randomized to two groups of 4 cadavers each. In Group 1, needle bevel direction at epidural entry was cephalad; in Group 2, it was caudad. After placement of each epidural catheter in L_4-L_5 interspace, 2 mL of radiopaque contrast was injected and a lumbar posterior-anterior radiograph was obtained. Catheter direction and direction of radiopaque contrast spread were collected.
Main Results: Due to the inability to access the epidural space secondary to surgical changes in the lumbar spine, one cadaver in the cephalad group was excluded. In 7 of 7 (100%) cadavers, the catheter tip direction according to the radiograph corresponded directly with bevel direction.
ConclusionsA strong relationship exists between bevel orientation and catheter direction; however, catheter position does not reliably predict the direction in which the injected fluid spreads in all cadavers.

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1. Introduction

In lower extremity surgery, direction of catheter insertion influences the efficacy of epidural anesthesia [1]. Bevel direction in the epidural space correlates with the directional spread of the injectate [2]. When a catheter is placed with the bevel of the needle facing in the cephalad direction in the mid-thoracic and low-thoracic spine, injected contrast spreads preferentially in the cephalad direction [3]. However, there are limited data assessing the direction of flow of the injectate when a catheter is threaded in the caudad direction. In this cadaver study, radiopaque contrast was used to confirm the relationship between bevel orientation, catheter direction, and radiopaque contrast spread in the lumbar region.

2. Materials and methods

After University of Medicine and Dentistry of New Jersey Institutional Review Board approval, 8 human cadavers were obtained from the anatomy laboratory. The cadavers were randomly divided into two groups of 4 cadavers. In Group 1, needle bevel direction at epidural entry was cephalad, while in Group 2 it was caudad. After each cadaver was placed prone, the L_4-L_5 interspace was identified using the posterior superior iliac crests as landmarks. We used anatomic landmarks because the study was performed in the medical school gross anatomy laboratory, where fluoroscopy was unavailable.

The cadavers were placed prone rather than in the lateral decubitus or sitting positions to eliminate the gravitational effect of the injectate on the spread, In addition, due to dermal and subcutaneous skin changes that occur as part of the embalming process, which make the tissues more rigid, and to eliminate differences in the way the epidural space was accessed, the decision was made to perform a cut-down with an 11 blade scalpel until the supraspinous ligament was reached at the L_4-L_5 interspace. Subsequently, an 18-gauge Touhy epidural needle was inserted into the interlaminar space via the midline approach using the "loss of resistance" to air technique with the bevel direction facing cephalad or caudad, based on random group assignment by a randomization software program. After the epidural space was entered, a single-orifice catheter was threaded 4 cm into the epidural space. After placement of each epidural catheter, 2 mL of radiopaque contrast (Omnipaque 300 GE Healthcare Inc., Princeton, NJ, USA) was injected and a lumbar postero-anterior radiograph was obtained. With 0.2 mL as the catheter dead space, the direction of spread was obtained with the remaining 1.8 mL of contrast.

3. Results

Due to our inability to access the epidural space secondary to surgical changes in the lumbar spine, one cadaver in the cephalad group was excluded. In 7 of 7 (100%) cadavers, the catheter tip direction according to the radiograph corresponded directly with bevel direction. In Group 1, the radiopaque contrast flowed primarily in the cephalad direction in all three cadavers. In Group 2, radiopaque contrast flowed primarily in the caudad direction in three cadavers and equally caudad and cephalad in the remaining cadaver.

4. Discussion

For patients undergoing total hip replacement, neuraxial anesthesia (spinal and/or epidural) results in better outcomes than general anesthesia [4]. According to Capdevila et al, regional techniques also improved early rehabilitation after major knee surgery by effectively controlling postoperative pain during continuous passive motion, hastening convalescence. [5]. In addition, for patients who are elderly and/or have multiple comorbidities, regional anesthesia may be preferred over general anesthesia, especially as epidural anesthesia may also be used for postoperative analgesia if these patients require overnight admission. However, for surgeries involving the ankle or foot, lumbar epidural anesthesia has not been a preferred technique, as there can be a sparing effect, particularly in the S1 region. This may be due to the large diameter of this nerve root compared with the other sacral roots [6].

Studies of the relationship of bevel orientation of the epidural needle on the direction of catheter placement have shown conflicting results. In one study, by Tiso et al, the results from 28 patients receiving lumbar epidural anesthesia with the catheter advanced 3 cm into the epidural space showed 80% concordance of catheter direction with the bevel of the Tuohy needle in the cephalad group (n = 15) and 46% concordance in the caudad group (n = 13) [7]. However, statistical analysis of this relationship was not performed since the relationship was not the primary goal for the study. However, in another study, by Choi et al, of 106 patients who received thoracic epidural anesthesia with the catheter advanced 5 cm into the epidural space, there was decreased concordance of catheter direction with the bevel of the Tuohy needle: 63.5% in the cephalad group (n = 53) and 22.0% in the caudad group (n = 53) [8]. One clear distinction between these two studies was the level at which the epidural space was injected [7,8]. Due to the anatomy of the epidural space, there is a narrower posterior depth of the epidural space in the thoracic region compared with the lumbar region, rendering advancement of the catheter in the thoracic region more challenging [8]. This increased resistance may have played a role in the decreased concordance of Choi et al's results. Further, placing a thoracic epidural requires greater angulation than does a lumbar, which may affect catheter direction. Our study results supported those of Tiso et al, in that bevel orientation correlated strongly with the direction of catheter placement in the lumbar region [7].

Bevel orientation of the epidural needle and direction of the spread of the injectate have not been absolute and conclusive. Data suggest that Touhy needle direction (caudad or cephalad)