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Alternative way to find sacral hiatus for blind caudal block – Based on 3D pelvis CT anthropometry: A retrospective study

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ABSTRACT

The aim of this study is to develop an alternative way to locate the sacral hiatus for blind caudal block from the anthropometrical data measured on 3D pelvic CT.

The intersection of the line connecting two sacral cornua and the midline is considered the ideal point (IP) for caudal block. The mean length from the coccyx tip to the IP was measured using 3D pelvic CT images in 30 men and 30 women and was 6.5 cm and 6.0 cm, respectively. For the conventional method group, we used the conventional equilateral triangle method to find the sacral hiatus, which was named conventional method group needling point (CNP). For the experimental method group, the point 6.5 cm or 6.0 cm (mean length from the coccyx tip to the IP) away from the coccyx tip was called the experimental method group needling point (ENP). Drawing the three points of the IP, CNP, and ENP on the same patient's 3D pelvic CT, we compared the distance from the IP to the CNP with the distance from the IP to the ENP. We propose that the experimental method is comparable to the conventional method in locating the sacral hiatus, which is crucial for a successful caudal block procedure.

Anthropometric measurements and virtual comparative test between two methods were done on the 3D pelvis CT.

In men, the distance from the CNP to the IP was 0.8 ± 0.5 cm in the conventional method group, while the distance from the ENP to the IP was 0.5 ± 0.4 cm in the experimental method group ($p < 0.05$). In women, the same distances were 1.5 ± 0.8 cm and 0.7 ± 0.3 cm, respectively ($p < 0.05$).

In conclusion, finding a point of 6.5 cm from the coccyx tip in men and 6.0 cm in women could be an alternative way to find the sacral hiatus for blind caudal block.

Introduction

A caudal block is a nerve blockage method in which a local anesthetic is injected into the sacral epidural space through the sacral hiatus. It is often used in anal and perineal surgeries, and also for chronic pain treatment [1–3]. As a result of the increasing popularity of perioperative procedures performed under ultrasound guidance in the operating room, there is a strong interest in whether ultrasound can be used in caudal block. In contrast to the approximately 74% success rate of blind caudal block, that is approximately 90–100% under ultrasound guidance [4–6].

In it thought that blind caudal block failure rates are high because the sacral hiatus varies in shape and size, and because it is difficult to distinguish the sacral hiatus from surface contour [7].

However, if an anesthesiologist is not allowed to use ultrasound, the blind technique is the only option for locating the sacral hiatus. Unfortunately, caudal block using the blind technique has a lower success rate than epidural block performed at the lumbar spine. Additionally, in obese patients it is even more difficult to locate the sacral hiatus by the conventional equilateral triangle method [8]. We therefore sought to determine a new easier method to find the sacral hiatus from the surface anatomy.

Hypothesis

According to the conventional equilateral triangle method, an equilateral triangle is drawn with the line connecting two posterior superior iliac spines (PSISs) as one side, and the lower vertex is regarded as the sacral hiatus (Fig. 2).

We tried to find a new way to locate the sacral hiatus based on anthropometric data from 3-dimensional (3-D) pelvis computerized tomography (CT) with easy. Instead of locating for the PSIS, mean

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length from the coccyx tip to sacral hiatus was used to find the sacral hiatus in the experimental method. To determine the clinical usefulness of this experimental method, we conducted virtual testing to compare the experimental method with the conventional method using 3D pelvic CT imaging of the same patient.

We hypothesis that the experimental method is alternative to the conventional method in finding the sacral hiatus, which is important factor for the successful caudal block procedure.

Methods

Approval was obtained from the Institutional Review Board of Daejeon St. Mary's Hospital to perform this study (DC16RISI0091). We selected pelvis CT images with three-dimensional CT reconstructions of the pelvis (Sensation 64 scanner, Siemens AG, Erlangen, Germany) from 30 male and 30 female patients who underwent hip arthroplasty surgery from January 2013 to March 2016. Slice thickness was between 2.0 and 3.0 mm. Scans were evaluated using the PACS software program (Marosis M-view, v 5.4.10.48, Marotech, Korea) after multiplanar reconstruction using Aquarius iNtuition Edition software (version 4.4.7.854.5213). Scans were analyzed using a process of dual consensus reporting similar to that described by Murphy et al. [9] CT images with artifacts due to metal inserted at a previous operation site or from revision cases were excluded.

To build the experimental method, we followed several steps. First, we defined the center of the sacral hiatus as the ideal point (IP) for needle insertion for caudal epidural block. The IP represents the point where the line connecting the two sacral cornua intersects with the midline. The length from the coccyx tip to IP was measured on 3D pelvic CT from each patient, and the mean value was called the mean ideal point length (mean IPL). Considering the curvature of the coccyx, the IPL was divided into three sections (IPL = a + b + c). The length from the coccyx tip to the sacrococcygeal joint (a), the length from the sacrococcygeal joint to the coccygeal cornu (b), and the length from the coccygeal cornu to IP (c) (Fig. 1).

First, we chose a sagittal 2D CT image of the coccyx taken from the midline. We measured the length from the coccyx tip to the sacrococcygeal joint (Fig. 1). Second, we measured the length from the sacrococcygeal joint to the tip of coccygeal cornu on the best sagittal view 2D CT image of the coccygeal cornu. Third, the distance from the coccygeal cornu to the IP was measured from the line connecting the two coccygeal cornu to the IP on the midline on a posterior view 3D pelvic CT image. Finally, IPL was calculated by the formula described above and was 6.5 cm for men and 6.0 cm for women (6.0 cm for women is an approximation of the 6.1 cm from the Table 1). According to the experimental method, the sacral hiatus is found at the mean IPL, 6.5 cm from the coccyx tip for men and 6.0 cm for women. The sacral hiatus located by this method was called the experimental method group needling point (ENP). Additionally, the distance from the IP to the cephalic end of the sacral hiatus was measured along the midline and was called the cephalic reserve of the sacral hiatus.

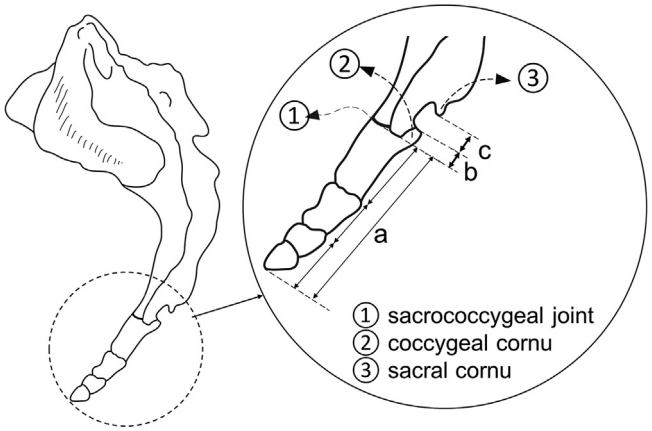

Fig. 1. Method for calculating the length from the coccyx tip to the ideal point (IP) of the sacral hiatus on 3D pelvic CT.

For the conventional method, we drew an equilateral triangle with one side connecting two PSISs, and the lower vertex was regarded as the sacral hiatus. The sacral hiatus located by this method was called the conventional method group needling point (CNP).

A virtual test was performed to determine the clinical usefulness of the experimental method compared to the conventional method. The sacral hiatus of the conventional method group was located using the conventional equilateral triangle method, while the experimental method group used the proposed method. The three points IP, CNP, and ENP were displayed on the 3D pelvic CT of the same patient. If the needling points were above the level of the IP, it was considered a cephalic placement, while points below the level of the IP were caudal (Fig. 2). The distances from the IP to the CNP and to the ENP were measured and are compared. The conventional method and experimental method groups were not discrete entities but different methods applied to the same patient's 3D pelvic CT.

Sample size was calculated by the following method. According to the results of a pilot study, the mean distance between the sacral hiatus determined by the two methods was 1 cm, with a standard deviation of 1 cm. We determined sample size using Chebyshev's inequality formula, because we did not know whether the distance between the sacral hiatus measured by the two methods would follow a normal distribution and could not locate any similar studies. The formula used was $P[-k < m - u < k] > 1-(\sigma^2/k^2n)$, $1 - \alpha = 1 - (\sigma^2/nk^2)$, where k is the difference required to detect the sample mean and population mean expressed as the number of standard deviations of distance between the sacral hiatus locations measured by the two methods. Using this formula, we calculated the sample size such that the mean difference between the sacral hiatus locations by the two methods was < 1 cm. We then set the power for the study at 80% with an error rate less than 0.05. After substituting the desired variables ($\alpha = 0.05$, $\sigma = 1$, $k = 1\sigma$), we obtained a study n of 20. In anticipation of a data loss of approximately 20% during the study, the sample size was set at 30 cases. In addition, we considered the potential for anatomical differences between the two sexes and thus established a final total study size of 60 cases.

Continuous variables are presented as mean ± standard deviation, and categorical variables are given as frequency (percent).

For statistical analysis, linear regression was used to determine whether the IPL correlated with patient age. Paired Student's t-tests were used for data that followed a normal distribution, and the Wilcoxon signed rank test was used for data that followed a non-normal distribution. A p value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 15 (SPSS Inc., Chicago, IL, USA).

Results

A total of 60 3D pelvic CT images from men (n = 30) and women (n = 30) were analyzed. The mean ages of the men and women were 72 and 78 years, respectively. The mean value of IPL was 6.5 ± 0.7 cm for men and 6.1 ± 0.8 cm for women. The lengths of the three sections that made up the IPL are shown in Table 1. Cephalic reserve was 1.2 ± 0.7 cm for men and 1.1 ± 0.7 cm for women.

The locations of the CNP and ENP were examined relative to the level of the IP. The CNPs were cephalic to the IP in 7/30 (23%) in men, 1/30 (3%) in women and were caudal to the IP in 23/30 (77%) in men, 29/30 (97%) in women. However, the ENPs cephalic to the IP in 15/30 (50%) in men, 12/30 (40%) in women and were caudal to the IP in 15/30 (50%) in men, 18/30 (60%) in women. There were significant differences in the distributions of CNP and ENP relative to the level of IP in men ($p < 0.05$) and women ($p < 0.01$) (Table 2).