Use of Magnetic Resonance Imaging to Define the Anatomical Location Closest to All Three Cords of the Infraclavicular Brachial Plexus

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Infraclavicular techniques are often used to perform brachial plexus blocks. In our volunteer study we used magnetic resonance imaging to identify the brachial plexus and axillary vessels in a sagittal plane corresponding to the lateral sagittal infraclavicular block. In 20 volunteers, all cords were positioned within 2 cm from the artery approximately within 2/3 of a circle. We derived an injection site that was closest to all cords, cranio-posterior and adjacent to the axillary artery. We conclude that this knowledge may be useful for the performance of infraclavicular blocks aided by ultrasound. However, our proposals should be tested by clinical studies.

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Infraclavicular brachial plexus blocks are widely used for anesthesia/analgesia distal to the shoulder (1–4). Single-injection techniques may be preferable to multiple deposits because of simplicity, patient satisfaction, and safety (5). The purpose of this study was to describe the anatomical variability, using magnetic resonance imaging (MRI), of the cord positions with respect to the axillary artery, and to determine a single-injection site that was closest to all three cords.

METHODS

MRI data from 20 healthy adult volunteers who had been examined for the development of the lateral sagittal infraclavicular block (LSIB) (6) were analyzed. After IRB approval, the volunteers were recruited and signed informed consent. The volunteers were examined in the horizontal supine position with arms at the side. They were scanned in a 1.5 T unit (Magnetom Vision; Siemens, Erlangen, Germany) using a three-dimensional (3D) spoiled gradient echo pulse sequence (3D FLASH) in the coronal plane (TR/TE = 4.4 ms/1.8 ms, flip angle = 30°, field-of-view = 300 × 300 mm^2, matrix = 256 × 256, number of excitations = 1, partition number = 64, partition thickness = 2.5 mm). Sagittal, axial, or oblique images were obtained from the 3D data set.

The basis for all measurements was a sagittal plane tangential to the medial surface of the coracoid process (6) (Figs. 1 and 2). The plexus, and axillary artery and vein were identified. The center of the artery was defined as datum point in a coordinate system with the x-axis horizontal in craniocaudal and the y-axis in anteroposterior direction. The centers of the lateral, medial, and posterior cords (L, M, P) were recorded as coordinates relative to the artery (A). All coordinates were plotted graphically. Average values used for the diameters were estimated from our previous study (6), involving the same volunteers: 8 mm for the artery, 10 mm for the vein, and 4 mm for the cords.

A target point T, closest to all three cords, should theoretically represent the most suitable position for injection. In a triangle with the vertices L, M, and P, the target point T was derived from the intersection point of the perpendicular bisectors. When T was situated outside the area of the triangle, its position was adjusted to the closest side of the triangle (Fig. 3). Subsequently, an optimal injection site $\bar{T}$ was defined as the average position of all the target points T. The calculated target points T and the average positions of the cords ($\bar{L}$, $\bar{P}$, and $\bar{M}$) were also plotted graphically. The position of $\bar{T}$ and the distribution of the cords were described by vectors with angles and distances to the center of the artery. Angles were measured in a clockwise direction from 0° (at the anterior position) to 360°. The distances of the cords to $\bar{T}$ were calculated. Measurements and calculations are presented as medians with 5th and 95th percentiles.

RESULTS

The volunteers were 10 women and 10 men with a mean age of 42 yr (SD, 12 yr), mean height of 173 cm

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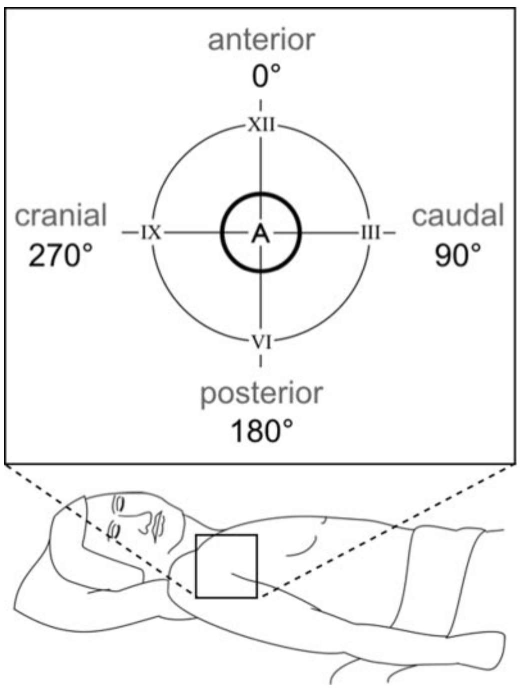

Figure 1. The sagittal plane corresponding to the LSIB was the basis for the measurements. The figure shows the orientation around the axillary artery (A), in degrees and on the clock face.

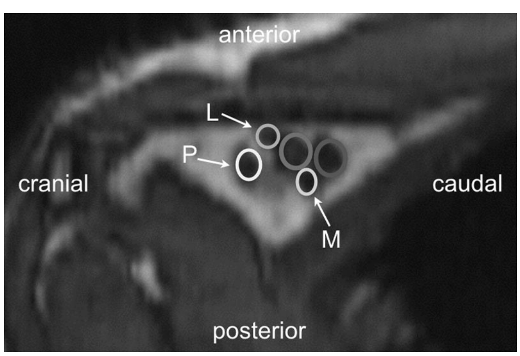

Figure 2. Magnetic resonance image of a volunteer obtained from a 3D data set. The image is reformatted in the sagittal plane corresponding to the LSIB. The lateral (*L*), posterior (*P*), and medial (*M*) cords and the axillary artery and vein are marked with circles. Positive identification of the cords and vessels could be achieved by tracking the structures in several planes obtained from the 3D data set. Measurements were performed electronically in the sagittal plane.

(SD, 8 cm), mean weight of 76 kg (SD, 15 kg), and mean body mass index of 25 kg/m^2 (SD 4.1 kg/m^2). Each volunteer had only one side scanned, but for each gender the right and the left sides were examined equally often.

The position of the cords was determined relative to the artery in the lateral sagittal plane (Fig. 4). The distance from the center of the cord to the center of the artery (presented as median with 5th and 95th percentiles) was 9 (4–18) mm at an angle of 276° (263°–321°) for the lateral cord, 9 (4–12) mm at 236° (189°–261°) for the posterior cord, and 7 (4–11) mm at 159° (90°–290°) for the *M* cord.

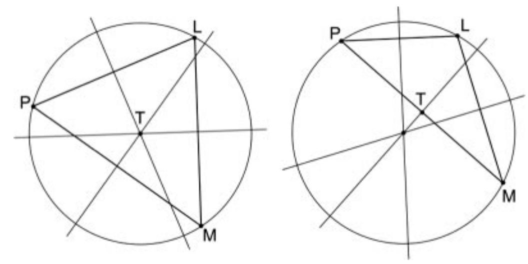

Figure 3. The position of the target point *T*, derived from the intersection point of the perpendicular bisectors, is situated inside the triangle (left). When *T* was situated outside the area of the triangle, the position of *T* was adjusted perpendicularly to the closest side of the triangle (right).

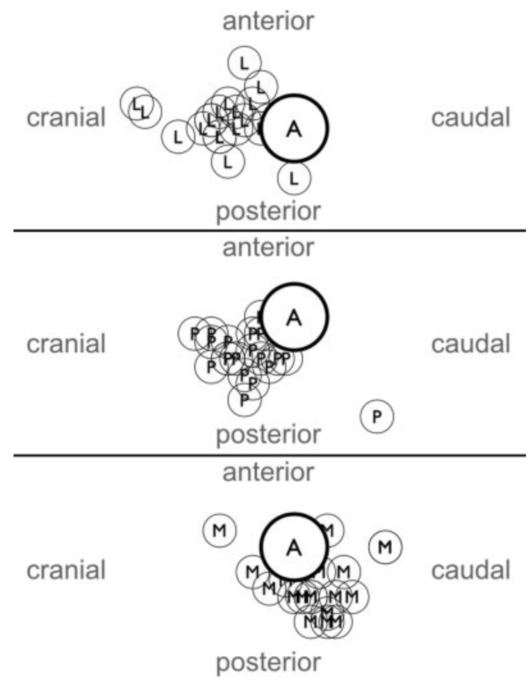

Figure 4. Positions of the lateral (*L*) (top), posterior (*P*) (middle), and medial (*M*) cords (bottom) in relation to the artery (A), for all volunteers.

The optimal injection site ($\bar{T}$) and the median positions of the cords ($\bar{L}$, $\bar{P}$, and $\bar{M}$—with median angles and median distance to the artery) are shown in Figure 5. The distance between $\bar{T}$ and the center of artery was 4 mm at an angle 235°. The optimal injection site ($\bar{T}$) had a median distance to the positions (centers) of the lateral, posterior, and medial cords of 7 (3–15) mm, 5 (2–9) mm, and 9 (4–14) mm, respectively.

DISCUSSION

Analysis of our MRI data in the sagittal plane of the LSIB (6) demonstrated that the cords were found within 2 cm from the center of the artery approximately within 2/3 of a circle. With reference to a clock face (Fig. 1) the cords were distributed between III and XI o'clock. Considering all volunteers, an average point with shortest distances to all cords was found at VIII o'clock, close to the artery, in the cranioposterior

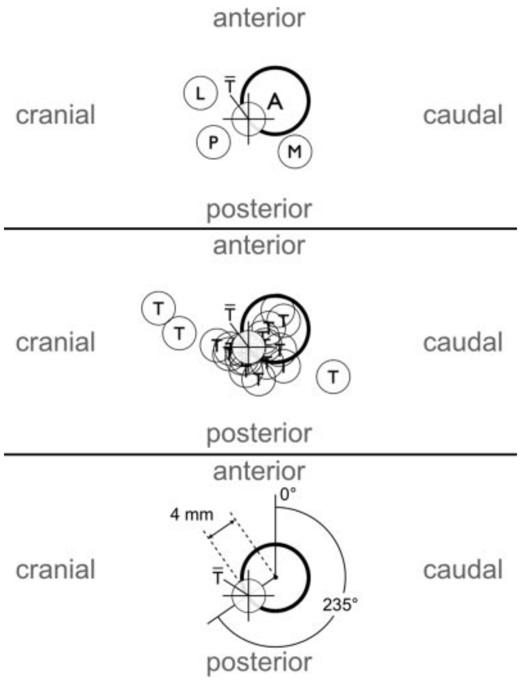

Figure 5. Optimal injection site $\bar{T}$. Top: $\bar{T}$ with median positions of the lateral (*L*), posterior (*P*), and medial cords (*M*). Middle: $\bar{T}$ with the target points (*T*) of all 20 volunteers. Bottom: $\bar{T}$ with angle and distance to the center of the artery.

quadrant. Injecting at this position may theoretically give efficient local anesthetic distribution to all cords.

Ultrasound guidance has been used frequently to perform brachial plexus blocks (7–9). However, the identification of nerve structures by ultrasound can be difficult in the infraclavicular region (10). Ultrasound visualization of the infraclavicular blood vessels is reliable (11), allowing ultrasound-guided needle placement at the suggested injection site at VIII o'clock. Observing satisfactory distribution of local anesthetic between III and XI o'clock may predict successful blocks.

The anatomy of the plexus varies widely among individuals. Hence, the small number of volunteers is a limitation of our study, and our data might not be representative. Further, our measurements only apply to a sagittal plane (6). We do not know whether the injection site suggested by MRI analyses, derived from scattered individual optimal target sites (Fig. 5), is actually optimal for ultrasound-guided blocks. Our proposals should be confirmed by clinical studies.

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