The position of the axillary nerve in the deltoid muscle

A cadaveric study

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In 134 deltoid preparations taken from 67 fresh cadavers we examined the position of the axillary nerve in relation to the upper border of the muscle. The vertical distances from the upper deltoid border to the nerve in 17 of 67 cadavers was less than 4 cm in both shoulders. The minimal distance, measured from the mid-middle portion of the deltoid to the axillary nerve, was 2 cm. There was a significant negative correlation between the deltoid ratio (width/length) and the vertical distance, measured in all examined sites. The shorter the deltoid length the greater the danger of damaging the nerve in the short distance during surgical splitting of the muscle.

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According to several authors, the axillary nerve is located about 5 cm from the tip of the acromion, and separation of the deltoid fibers more than 4 cm from this tip is not recommended (Hollinshead 1969, Hoppenfeld and de Boer 1984). Rockwood (1984) has noted that posteriorly the nerve exits from the lower border of the teres minor 10–12 cm from the tip of the acromion, so it is in less danger during the posterior deltoid-splitting approach to the shoulder. A few post mortem studies have examined the variability of the axillary nerve position in relation to certain acromial sites (Burkhead et al. 1992, Kulkarni et al. 1992, Nassar et al. 1997). Our study is based on a larger number of fresh cadaveric specimens. It records the variation of the axillary nerve position in relation to the upper deltoid border and examines the role of the deltoid dimensions in the estimation of the nerve position.

Material and methods

134 deltoids from 67 fresh cadavers (median age 63 (18–84) years, 39 men) were dissected sharply from their insertions. The axillary nerve was cut before it entered the quadrilateral space and it was delivered with some fibers from the teres minor. The deltoid was exposed flat on the table. Thus we could see the entire course of the axillary nerve in the deep surface of every deltoid preparation. The axillary nerve passing the quadrilateral space gives off a branch for the teres minor and sequentially divides into 2 branches. These branches follow a common course until they meet the deltoid muscle. The posterior branch runs to the posterior deltoid entering the muscle where it gives off 2 or 3 branches for the posterior deltoid and one branch for the innervation of the skin of the lateral deltoid area. The anterior branch passes to the middle and the anterior deltoid (where it enters the muscle), giving off 7–8 branches; it is responsible for the innervation of these deltoid regions. The vertical distances from the anterior upper border of the deltoid to the axillary nerve in the site it enters the muscle belly anteriorly—anterior entering point— (ant), from the mid-middle upper deltoid border to the nerve (mid), from the upper deltoid border to the site where both divisions of the nerve meet, the muscle in the region between the posterior and the middle deltoid (mp), from the upper deltoid border to the site where the nerve enters the muscle belly posteriorly—posterior entering point—(post), as well as the horizontal distances between the anterior (h-ant) and posterior deltoid borders (h-post) to the entering points of the nerve were measured. These two last measurements were made to indicate the points from which the distances (ant) and (post) were measured. For each cadaver we estimated the mean values of the distances between the right and left deltoid in each measurement site. The width and the length of each deltoid

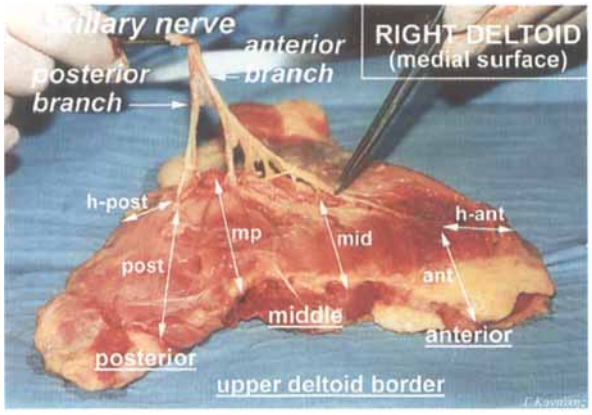
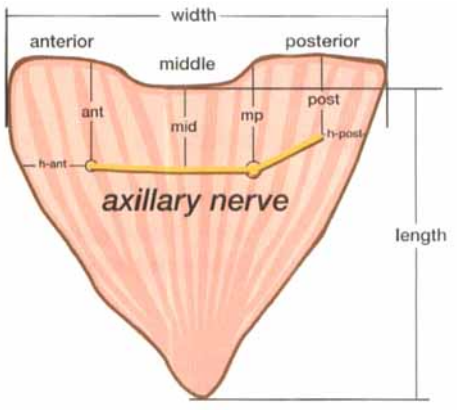


Figure 1. A. Photograph of a deltoid specimen.



B. Line drawing showing the medial surface of the removed deltoid and the position of the axillary nerve.

Table 1. The mean vertical distances of the axillary nerve from the upper deltoid border and the mean horizontal distances from the anterior and posterior borders, as measured in 67 cadavers

	Vertical distances in cm				Horizontal distances in cm	
	ant	mid	mp	post	h-ant	h-post
Mean (SD)	4.5 (1.2)	4.6 (1.2)	5.6 (1.3)	5.0 (1.3)	4.3 (1.1)	2.9 (1.1)
Range	2.5–6.5	2–6	4–7.5	3–7.5	3–6	2–4
99% CI	4.0–4.9	4.2–4.9	5.1–6.0	4.5–5.4	3.9–4.6	2.5–3.2

were measured and the deltoid ratio (width/length) was calculated (Figure 1). The mean value between the right and left deltoid ratio was the mean deltoid ratio for each cadaver. All the measurements were done independently by three examiners and the average of these measurements was calculated. The correlation between the several mean vertical distances and the mean deltoid ratio was determined.

Statistics

Data are presented as mean (range) values and the 99% confidence intervals (CI) of the means. Linear regression analysis was used to determine the relation between vertical distances and the mean deltoid ratio. To determine the inter-examiner variation, the difference between the deltoid distances D_{max}–D_{min} in each measurement site of the muscle, where D_{max} and D_{min} the maximum and the minimum measured distance, respectively, was expressed as a percentage of the highest value D_{max}.

Results

The mean difference in deltoid distances at several measurement sites, as performed by the three examiners, was found to be 4.2 (1.9–6.2)%. The vertical and the horizontal distances between the deltoids of the same cadaver were equal in most specimens or the differences between them were less than 1 cm (Table 1). In 3 cases (2 women), however, there was a difference of 1–2 cm in the position of the nerve between the left and right sides. The width and the length of the deltoids in each cadaver were equal between right and left or differed by less than 1 cm. A statistically significant negative correlation was found between the mean deltoid ratio and the distance from the upper deltoid border to the nerve in all the measured sites ($p < 0.001$, Table 2). In 8 of 39 men, and in 9 of 28 women (total 25 % of the cadavers), the axillary nerve's vertical distance from the upper border of the deltoid was less than 4 cm in both shoulders, having a minimal measured distance of 2 cm. The axillary nerve was located a mean of 2.6 (1.7–3.4) cm above the midpoint of the vertical plane (length) of the deltoid.

Table 2. The correlation of the mean deltoid ratio (width/length) with the mean values of the measured vertical distances ($p < 0.001$), 67 cadavers

Deltoid ratio	ant	mid	mp	post
r	–0.36	–0.63	–0.41	–0.57

Discussion

The avoidance of injury to the axillary nerve during open or arthroscopic surgery of the shoulder is a common concern for surgeons. Abbott et al. (1949) stated that incisions made with separation of the fibers of the deltoid should not extend downward for more than one and a half inches below the margin of the acromion. However, this is not based on a known number of observations.

The distances we measured in this study concern the entire position of the axillary nerve. The removal of the deltoid from its original position did not affect the location of the axillary nerve in the medial surface of the deltoid, in relation to the upper border of the muscle.

The position of the axillary nerve in the deltoid, according to several anatomic textbooks, is unclear (Johnston and Whillis 1946, Gardner et al. 1975, Basmajian 1978, Ellis 1983). A cadaveric study showed that the axillary nerve is 2.2–2.6 cm above the midpoint of the vertical plane of the muscle (Kulkarni et al. 1992). In our study, we noticed a greater variation between the respective values. Burkhead et al. (1992) studied the axillary nerve in 51 embalmed and 5 fresh cadaveric specimens. They found that in nearly one fifth of the cadavers the nerve at some point in its course around the humerus in the deltoid muscle was less than 5 cm from the palpable edge of the acromion and at a minimal distance of 3.1 cm. The difference in the material in this study (fresh cadavers) or differences in population characteristics may be responsible for the greater percentage we noticed.

According to our measurements, the posterior deltoid-splitting exposure (Rockwood 1984, Wirth et al. 1993) is safe only when the splitting is strictly between the posterior and the middle deltoid.

In a recent anatomic study (Nassar et al. 1997), the axillary nerve index was described as the ratio between the distance of the nerve from the acromioclavicular joint and the length of the deltoid from the anterior clavicular line and this was proposed as a useful guide for estimation of the position of the nerve at the time of surgery. The deltoid ratio, as shown by us, is useful for estimation of the position of the nerve in its entire course, especially the vertical distance from the middle of the acromion. Our study causes more hesitation in surgical spitting of the deltoid. In one quarter of the cases, the splitting of the deltoid may lead to nerve injury. Taking into account the dimensions of the deltoid, the surgeon can protect the nerve during surgery. The shorter the deltoid length, the greater the danger of damaging the nerve at a short distance from the upper border of the muscle.

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