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CLINICAL REPORT

Ultrasound imaging of the musculocutaneous nerve of infants, preschool children, and school children

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Abstract The purpose of this imaging study was to investigate whether the musculocutaneous nerve could be visualized ultrasonographically in childhood and to assess how its visualization changes with age. Forty-two children participated in this prospective imaging study. The musculocutaneous nerve was sought both proximally (near the axillary artery) and distally (within the coracobrachialis muscle) by use of an linear ultrasound probe. Location of the musculocutaneous nerve was good (93 %) for all the children, both proximally and distally. For school-aged children, distal visualization of the musculocutaneous nerve reached 100 %. The musculocutaneous nerve is detectable in childhood by use of ultrasonography; success of detection was high for all the age groups examined.

Keywords Children · Infants · Musculocutaneous nerve · Ultrasonography

Introduction

Use of ultrasound-guided peripheral blockade for children has increased in the last decade [1, 2], because ultrasonography (US) facilitates visualization of anatomic structures, and recognition of the variable courses of nerves [3]. Many orthopedic procedures of the upper extremities of children can be performed by application of axillary block, usually combined with general anesthesia.

The musculocutaneous nerve (MCN), one of the terminal branches of the brachial plexus, arises principally from the fifth and sixth cervical nerves. Clinical evidence from patients with lesions of C5 and C6 suggests that the contribution from C7 is negligible [4]. The MCN extends laterally to the median nerve, passing through the coracobrachialis muscle, running distally between the biceps brachii and brachial muscle. It has three motor branches (for the coracobrachialis, biceps brachii, and brachial muscles) and ends with the terminal sensitive lateral cutaneous antebrachial nerve, which supplies the lateral aspect of the forearm [5].

Although immediately after birth the functional anatomy of the brachial plexus differs between children, and between adults and children, because the nervous system is not fully developed at this stage [6], there is limited information about early imaging of the anatomy of the brachial plexus and, in particular, the MCN.

Locating the MCN for neural blockade is crucial to achieving complete anesthesia of the forearm. For up to 40–50 % of children, however, the musculocutaneous nerve cannot be blocked when plain neurostimulation is used [6, 7], and traditionally it has been regarded as undetectable by ultrasonography [1, 8]. It is worth noting that although there is sufficient information about US imaging of the MCN for adults [3, 8–11], no data are available for children.

The primary purpose of this imaging study was to investigate whether or not the musculocutaneous nerve could be visualized in childhood by use of ultrasound imaging. A secondary purpose of the study was to assess the effect of age on percentage visualization.

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Case report

This prospective imaging study was performed at the "Attikon" University Hospital (Athens, Greece). The study protocol was approved by the Attikon University Hospital Ethics and Research Committee (President Professor Ch. Liapis; no of decision 12/1-12-10; topic 4). Parental written informed consent was obtained for all participants. The trial was post-registered in clinicaltrials.gov (registration number NCT02168699). Exclusion criteria included parent's or children's refusal to participate in the study, previous operations on, or anatomical malformation of, the axillary fossae or the proximal regions, spasticity (plasticity), and morbid obesity.

We included any new child admitted to the pediatric department of our hospital for hospitalization, assuming the child did not meet the exclusion criteria and we could obtain parental informed consent. The children were divided into three groups according to age: Group 1, infants aged less than 12 months; Group 2, toddlers and preschool children; and Group 3, school-aged children (6.5–12 years). Assignment of new children continued until we had examined 14 subjects in each age group. When one group became full, with 14 children, we discontinued assignment of new subjects to this particular age group.

Ultrasound examination of the axillary region was performed by an experienced anesthesiologist in ultrasound-guided regional anesthesia, with the children awake in the pediatric ward. A portable ultrasound machine (Logiq Book XP with 8L-RS probe; GE Healthcare, USA) was used. Children were placed in the supine position with the involved arm abducted at 90° and the elbow flexed at 90°. The probe was placed at the axillary region, perpendicular to the axillary artery. The musculocutaneous nerve was sought near the axillary artery (proximally) and its course was followed distally (into the coracobrachialis muscle). Its sonographic detection was recorded at these two sites, both proximally and distally. MCN visualization was regarded as impossible for a particular child when the MCN could not be detected as a separate nerve despite adequate visualization of the axillary artery, median nerve, and muscles (biceps and coracobrachialis).

Descriptive statistical analysis was performed by use of SPSS v.15.0. Power analysis was based on the first 10 patients for whom the lowest proportion of successful imaging of the MCN was 0.90 (9 out of 10 patients). On the basis of common power analysis for proportions [12], the number of patients needed to achieve a 95 % confidence interval of ±7.5 % (total width of 0.15), was estimated to be 12 in each group.

Forty-two children were included in the study; 14 children in each group. Of the children eligible for our study there were no missing patients. Imaging success, both proximally and distally, was good for all groups; for school-aged children distal location of the MCN reached 100 %. For a unique subject (1/14) from Group 1 (infants) and a unique subject (1/14) from Group 2 (toddlers and preschool children), visualization of the MCN was impossible both proximally and distally. Demographic data and visualization success are listed in Table 1.

During the study it was found that slight elevation of the axillary fossae, by placing the hand of an assistant beneath the ipsilateral shoulder, increased imaging success for infants younger than 8 months (Fig. 1a, b). In this age group, the aforementioned maneuver increased the success of visualization from 0 to 70 % during proximal location and from 0 to 80 % during distal location.

Discussion

This study achieved highly successful ultrasound detection of the MCN in childhood. Both proximal and distal location success was high (93 %) for all the groups examined; for school-aged children distal location of the MCN was successfully achieved for all participants. In the past few years, progressive improvement of ultrasound transducers and new developments in signal-processing software for sonography have led to continuing improvement of image contrast and detail resolution in examination of superficial soft tissues [3]. The difficulty of identifying the MCN for children in the older literature [1, 8] could be explained by the different quality of ultrasonic diagnostic equipment.

Table 1 Demographic data and visualization success for the three groups

	Age	Weight (kg)	Height (m)	BMI	Proximal location	Distal location
Group 1 ($n = 14$)	5.3 ± 4.0 (months)	6.4 ± 2.0	0.63 ± 0.08	16.0 ± 2.5	93 %	93 %
Group 2 ($n = 14$)	4.1 ± 1.8 (years)	17.7 ± 5.8	1.03 ± 0.17	16.6 ± 3.1	93 %	93 %
Group 3 ($n = 14$)	8.9 ± 1.8 (years)	37.1 ± 14.4	1.37 ± 0.12	19.3 ± 5.2	93 %	100 %

Age, weight, height, and BMI are expressed as mean values ± SD

Group 1: <12 months (infants)

Group 2: 13 months–6 years (toddlers and preschool children)

Group 3: 6.5–12 years (school-aged)

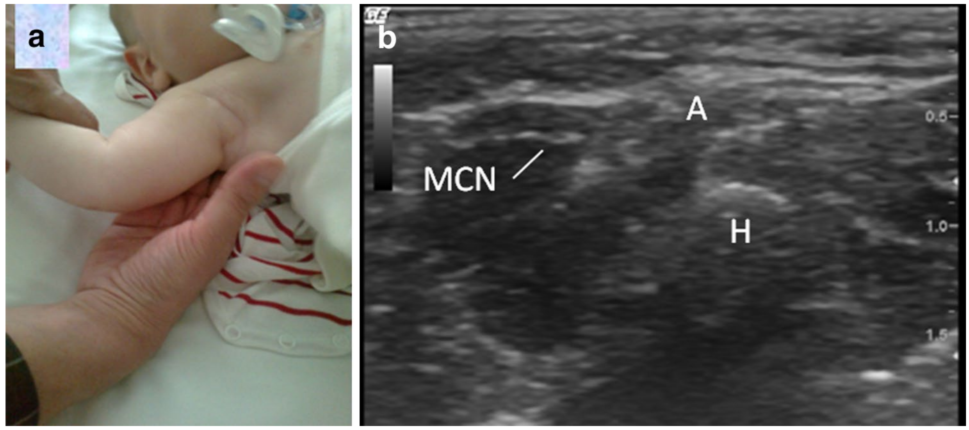

Fig. 1 **a** Elevation of the axillary fossa, by placing the hand of an assistant beneath the ipsilateral shoulder of the infant, resulted in better visualization of the musculocutaneous nerve. **b** Ultrasound image of the axillary region of an infant (4 months old). *MCN* musculocutaneous nerve, *H* humerus, *A* axillary artery

It is worth remarking that for infants younger than 8 months, slight elevation of the axillary fossae by placing the hand of an assistant beneath the ipsilateral shoulder of the infant, enabled visualization of the MCN; this was not possible with the typical positioning used for the older infants and children. A rational explanation could be that the limited area of infant's axillary region made full contact of the probe with the skin difficult, thus positioning of an examiner's hand under the shoulder of small children facilitated elimination of this obstacle. Furthermore, this maneuver enabled us to achieve better visualization of the MCN, possibly because of a change in the angle of the nerve to the plane of the ultrasound.

It has been reported that among anatomical variations of the axillary brachial plexus, variations of the MC nerve have been reported most frequently [9]. Anatomical [13] and ultrasound [7–10, 14] studies performed on adults have revealed that the MCN can be fused to the median nerve in a common trunk. This atypical pattern of branching could explain some our cases in which detection of the nerve was impossible for children, although any atypical position of the nerve should be confirmed by neurostimulation.

In our study, identification of the MCN was based on its typical hyperechoic structure, its position in relation to the axillary artery, and the possibility of tracking this structure sonographically proximally toward the axillary artery and distally within the coracobrachialis muscle. Thus, a potential limitation of our study is the absence of confirmation of our results by neurostimulation, indicating the need for further investigation to enhance the clinical significance of our findings. An additional limitation of any imaging study is the effect on the results of the ultrasound system and the anesthesiologist's ultrasound skill.

Our results for the success of MCN detection for children were similar to previous results for adults. Schafhalter-Zoppoth and Gray, in a descriptive imaging study, investigated both the success of US detection and the shape of the MCN for 18 adult volunteers; their success at visualizing the MCN was similar to ours [11]. In a recent sonographic study [9] performed on adults, however, there was no case in which the MCN was not observed. The authors explained this finding on the basis of the limited number of subjects examined, more proximal positioning of the probe, or, perhaps, racial differences.

Finally, in our study the morphology of the MCN could be described as flat oval for all the subjects examined whereas Schafhalter-Zoppoth and Gray reported a change in the shape of the MCN from oval to flat–oval to triangular during its course from the axillary fossae to the coracobrachialis muscle [11].

In conclusion, we have shown that the MCN is detectable in childhood, both proximally and distally, by use of ultrasonography. By use of ultrasonography we achieved highly successful detection of the MCN in infants, preschool children, and school-age children. For infants younger than 8 months, slight elevation of the axillary fossae, by placing the hand of an assistant beneath the ipsilateral shoulder of the infant, enabled visualization of the musculocutaneous nerve.

Conflict of interest The authors declare that this work was not supported by any funding program and they have no conflict of interest.

Ethical standards The authors declare that the study complies with the current laws of their country.

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