Annals of Anatomy 208 (2016) 40–48

Contents lists available at ScienceDirect

Annals of Anatomy

journal homepage: www.elsevier.com/locate/aanat

Research article

Variations in brachial plexus with respect to concomitant accompanying aberrant arm arteries

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ARTICLE INFO

Article history:
Received 30 May 2016
Received in revised form 11 July 2016
Accepted 26 July 2016

Keywords:
Brachial plexus
Variations
Cords of brachial plexus
Loop of median nerve
Median nerve
Musculocutaneous nerve
Arm arteries

ABSTRACT

Introduction: Variations in the brachial plexus are the rule rather than the exception. This fact is of special interest for the anesthetist when planning axillary block of brachial plexus.
Material and methods: 167 cadaver arms were evaluated for variations in brachial plexus, with focus on the cords of the plexus, the loop of the median nerve, and the course of the median, musculocutaneous, ulnar, axillary and radial nerves. In addition, concomitant arterial variations were recorded.
Results: In 167 arms, variations were detected in 60 cases (36%). With 46 arms (28%) most variations concern the median nerve, followed by 13 cases (8%) which involved the musculocutaneous nerve. Ulnar, axillary and radial nerve variations were rare, amounting to 1.2% for each nerve. In median nerve conditions with a shifted loop of median nerve (12%), a hidden position of the loop or a hidden course of the beginning median nerve (8%) and a doubled loop of median nerve (17%) were observed. In musculocutaneous nerve conditions with a non-perforated coracobrachialis (1.8%), a doubled origin of the nerve (1.2%) and a giving back of branches to the median nerve (1.8%) were noted. Variations in ulnar, axillary and radial nerves concerned lower than normal diameters.
Conclusions: It must be stressed that cases which showed a hidden position or a doubled expression of the loop of the median nerve, a hidden course of its beginning and variable interconnections between musculocutaneous and median nerves are of special interest for anesthetists and surgeons. Hence, it is important to note that variations of arm arteries can be associated with brachial plexus variations. For example, a common trunk of axillary artery followed by a hidden loop and course of the median nerve may result in incomplete axillary block of brachial plexus.

1. Introduction

In textbooks of the early 19th century, variations in the brachial plexus (Meckel, 1817; von Luschka, 1865) were not described. Henle (1871) and Hoffmann (1881) were the first to report that the connections and the origins of brachial plexus branches were not developed uniformly. In the Anglo-American literature, Walsh (1877) and Kerr (1918) referred to the anatomical variation in the brachial plexus. Later on, this variability was confirmed in the textbook of Rauber and Kopsch (Kopsch, 1950). Especially the location of the loop of the median nerve is highly variable (Leonhardt in Rauber-Kopsch, 1988; Tillmann in Zilles/Tillmann, 2010). The supplies by the lateral or medial cord may be two-, three- or even fourfold (von Lanz and Wachsmuth, 1959; Leonhardt in Rauber-Kopsch, 1988; Tillmann in Zilles/Tillmann, 2010). The loop of the median nerve may lie behind the axillary artery (Gegenbaur, 1892; Gegenbauer, 1903) or may have moved to the distal upper arm (von Lanz and Wachsmuth, 1959; Leonhardt in Rauber-Kopsch, 1988; Tillmann in Zilles/Tillmann, 2010). Further on, some of the fibers of the median nerve may run for some distance in the musculocutaneous nerve and then leave it to join their proper trunk (Williams and Warwick in Gray, 1980). Besides the normal loop of the median nerve, a connection between median and musculocutaneous nerves may form an additional loop. In about 5% of cases, the median nerve's loop is absent (Leonhardt in Rauber-Kopsch, 1988; Tillmann in Zilles/Tillmann).

The next most frequent variants in the brachial plexus concern the musculocutaneous nerve. A connecting branch between median nerve and musculocutaneous nerve is observed in quite a number of cases (Kopsch in Rauber-Kopsch, 1914, 1950; Leonhardt in Rauber-Kopsch, 1988; Tillmann in Zilles/Tillmann, 2010). Instead of piercing the coracobrachialis muscle, the musculocutaneous

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http://dx.doi.org/10.1016/j.aanat.2016.07.007
0940-9602/

nerve may pass behind this muscle to the lateral upper arm (Gegenbaur, 1892; Gegenbauer, 1903). Furthermore, this nerve may adhere for some distance to the median nerve and then pass behind the biceps instead of through the coracobrachialis muscle (Williams and Warwick in Gray, 1980). After perforation through the coracobrachialis muscle, the trunk of the musculocutaneous nerve was seen to receive fibers from the median nerve or to send fibers to it (Gegenbaur, 1892; Gegenbauer, 1903). At least, the musculocutaneous nerve may be a branch of the median nerve (Gegenbaur, 1892; Gegenbauer, 1903).

Analyses of brachial plexus seldom focussed on trunks, cords and the upper arm-route of the 5 long nerves. Therefore, we examined the variation in the 5 main brachial plexus nerves with regard to their formation at the level of the axillary artery and their course through the upper arm. In previous studies we have referred to variations of arm arteries (Claassen et al., 2006, 2010). Since we observed that a variant location of the loop of the median nerve sometimes is accompanied by an arterial variation, we additionally examined the course and the branches of arm arteries.

2. Material and methods

In the summer terms 2009 (13 arms), 2010 (32 arms), 2011 (45 arms), 2012 (31 arms) and 2014 (46 arms) the upper extremities dissected in the gross anatomy courses at the Department of Anatomy (University of Rostock) were inspected for variations in the brachial plexus and especially for the concomitant occurrence of variant arm arteries. The topography of variant plexus branches and their relation to the surrounding arteries and muscles was documented on diagrams and photographs. This study was approved by the ethics committee of the University of Rostock (A-2016-0083) and followed the guidelines of the Declaration of Helsinki.

3. Results

In summary, the present sample of 167 arms revealed variations of the brachial plexus in 60 arms (36%). Gender-specific variations were not observed. Here we firstly present a survey of the variations in the brachial plexus (Table 1). Selected, especially interesting cases are described in a second step.

3.1. Overall description of the cases

Median nerve: 167 arms were investigated and variations of the median nerve, especially concerning the loop of the median nerve, were found in 46 cases (28%). Variant locations of the loop of the median nerve were summarized in a diagram (Fig. 6). In 29 cases, the variation was on the right side and in 17 on the left side respectively. The following description comprises three categories:

In the first group the fork of the median nerve was not located at its normal place:

- in 5 cases (3%) the loop had moved slightly on axillary artery,
- in 14 cases (8.4%) the loop had moved to the beginning or to the upper third of brachial artery,
- in 1 case (0.6%) the loop had moved to the middle of brachial artery,
- in only 1 case (0.6%) the loop was missing.

In the second group we put cases where the loop of the median nerve presented a location to a distinct artery, especially a variant arm artery:

- in three cases (1.8%) the loop of the median nerve was located behind the axillary artery,
- in one case (0.6%) the loop surrounded the subscapular artery,
- in two cases (1.2%) the loop was found behind the brachial artery,
- in one case (0.6%) the loop covered the profunda brachii artery,
- in one case (0.6%) the loop covered a variant superficial ulnar artery with high origin.

The third group comprises cases with a doubled loop of the median nerve:

- one case (0.6%) with doubled loop, the first one at the normal place, the second one near to the normal place,
- one case (0.6%) with doubled loop, the first one at the normal place, the second one at the beginning of the brachial artery,
- nine cases (5.4%) with doubled loop, the first had moved somewhat distally, the second was located at the proximal third of the brachial artery,
- five cases (3%) with doubled loop, the first one at the normal place, the second one was located at the middle of the brachial artery,
- one case (0.6%) with doubled loop, the first one at the normal place, the second one was found behind the high origin of a radial artery.

Musculocutaneous nerve: 167 arms were investigated and variations of the musculocutaneous nerve, especially regarding its relation to the coracobrachialis muscle, were found in 13 cases (8%). In 5 cases the variation was located on the right side and in 8 on the left side, respectively. Our description comprises three categories:

Cases with an aberrant origin of the musculocutaneous nerve or with a non-perforation of the coracobrachialis muscle were included in the first group:

- one case (0.6%) with a high origin of the musculocutaneous nerve,
- one case (0.6%) with a low origin of the musculocutaneous nerve,
- in three cases (1.8%) the musculocutaneous nerve did not perforate the coracobrachialis muscle, but instead showed a connection to the biceps brachii muscle,
- one case (0.6%) with a thin musculocutaneous nerve,
- in one case (0.6%) a musculocutaneous nerve was missing altogether.

The second group contains cases with doubled origin of the musculocutaneous nerve:

- one case (0.6%) of doubled origin of the nerve, the first origin was found within the loop of the median nerve, the second detected within the median nerve itself at the middle of the upper forelimb,
- one case (0.6%) of doubled origin of the nerve, the first one was observed within the lateral root of the loop of the median nerve, the second one was built by the median nerve itself at its beginning.

The third group consists of cases where the musculocutaneous nerve sent branches back to the median nerve or took its origin directly from the median nerve:

- in three cases (1.8%) the musculocutaneous nerve sent branches back to the median nerve or returned with parts to it,
- in one case (0.6%) the musculocutaneous nerve took its origin directly from the median nerve in the middle of the upper forelimb.

Ulnar nerve: within 167 arms the ulnar nerve showed variations in 2 cases (1.2%). In one case, the nerve derived very late from the lateral cord or almost from the median nerve. In another case, the ulnar nerve was thinner than normally at its beginning.