STUDY OF THE ANATOMICAL VARIATIONS OF THE MEDIAN NERVE IN HUMAN FOETUSES AND THEIR CLINICAL IMPLICATIONS

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ABSTRACT

BACKGROUND

Median nerve is one of the most important terminal branches of the brachial plexus. Anatomical variations in the formation of the median nerve are common and have been reported by several authors.

METHODS

Dead foetuses from Government General Hospital**,** Kurnool were collected within 10 hrs after death. All the foetuses were stillborn at different stages of gestations. Depending on the size of foetus, 10% formalin was injected either into the vessels or into the abdominal cavity, thoracic cavity and into the cranial cavity. After embalming, these foetuses were immersed in buckets containing 10% formalin. Dissection of foetuses was taken up 48 hrs. after embalming so that all the tissues are fixed and firm. To expose the brachial plexus and median nerve a systematic dissection procedure was adopted.

RESULTS

In the present study, the following variations were observed in the arms of two different foetuses: In specimen no. F12 and specimen no. F39- in left upper limb, an abnormal communication was seen between musculocutaneous nerve and median nerve (figure 1), (figure 2). In the present study, an abnormal innervation by a muscular branch of median nerve to the flexor digiti minimi muscle of hypothenar eminence was observed in specimen no. F. 26 right upper limb (Figure 3).

CONCLUSIONS

A detailed knowledge of the median nerve with its variations helps surgeon to plan for reconstructive surgery of hand in situations like crush injury, birth injury, malignancy, compression of median nerve in carpal tunnel syndrome which is now a frequent occurrence in computer professionals.

KEYWORDS

Foetus, Median Nerve, Musculocutaneous Nerve

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BACKGROUND

The median nerve is formed by two roots, one from lateral cord with the root value of C5, C6, C7 and the other from the medial cord with root value of C8, T1. The roots of the median nerve are closely related to the third part of the axillary artery. Some of the fibres from C7 leave the lateral root of the median nerve and pass distally and medially behind the medial root just in front of the axillary artery to join the ulnar nerve.

Course

In the Axilla:

Lateral root of the median nerve derived from the lateral cord is lateral to the third part of the axillary artery. The medial root of the median nerve crosses the axillary artery anteriorly and joins the lateral root and forms the median nerve. The median nerve now lies lateral to the axillary artery.

In the Arm

The median nerve descends into the arm lying lateral to the brachial artery and at about the level of insertion of the coracobrachialis it crosses anterior to the artery and descends on its medial side till the nerve reaches cubital fossa. Here it courses between the bicipital aponeurosis and brachialis muscle.

In the Forearm

The nerve usually enters the forearm between the two heads of the pronator teres muscle, crossing the ulnar artery from medial to the lateral side. The median nerve passes deep to the tendinous arch that connects the humeroulnar and radial heads of the flexor digitorum superficialis muscle. The nerve descends deep to the flexor digitorum superficialis muscle. About 5 cm proximal to the flexor retinaculum it emerges from behind the lateral edge of the flexor digitorum superficialis and then descends between the tendons of the flexor digitorum superficialis and flexor carpi radialis. It then

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passes deep to the flexor retinaculum i.e. in the carpal tunnel to enter the palm. In the lower part of the forearm it is accompanied by a branch of the anterior interosseous artery.

In the Palm
At the distal border of the flexor retinaculum the nerve is slightly thickened and flattened. It usually divides into medial and lateral divisions which further divide into 5 or 6 branches at variable levels.

Branches of the Median Nerve

- In the Arm
  1. Vascular branches to the brachial artery.
  2. Muscular branch to the pronator teres.
- In the Forearm
  1. Muscular branches to pronator teres, flexor carpi radialis, palmaris longus and flexor digitorum superficialis.
  2. Articular Branches to elbow joint and proximal radioulnar joint.
  3. The Anterior Interosseous Nerve.
  4. The Palmar Cutaneous Branch.
  5. The Communicating Branch.
- In the Palm
  Muscular Branch to flexor pollicis brevis, abductor pollicis brevis and opponens pollicis.
- Palmar Digital Branches

We wanted to collect detailed information about the formation, course, termination and branches of median nerve in foetuses, as it has been considered to be an essential information for proper planning of corrective surgeries and provide additional information about the variations of the median nerve.

METHODS

50 dead foetuses of different age groups were collected from Government General Hospital. Most of the specimens were of intrauterine deaths or premature deliveries resulting in neonatal death. All the 50 foetuses were preserved in 10% formalin after injecting 20 to 100cc of 10% formalin into cranial cavity and trunk (Thorax and Abdomen) depending on the size of foetus.

A. Length of Foetus

Crown rump lengths of all foetuses were measured in centimeters to assess the approximate age of the foetuses in weeks.

B. Weight of Foetus

The weight of all the foetuses along with 5 to 6 cm of umbilical cord was taken in grams with the help of a simple balance with pans.

C. Cranial Diameters

Biparietal diameter i.e. distance between two parietal eminences of all the specimens was measured with Vernier calipers to assess the normal development of brain.

Sl. No.	Age in Weeks	Weight in Grams	C.R.L. in cms	B.P.D. in cms
1.	24	1125	24	8.5
2	23	650	21.5	7.5
3	22	640	20.5	7
4	18	325	17	6
5	30	1900	29	9.5
6	19	400	18	4.5
7	22	670	21.5	10
8	31	1950	29	10.5
9	30	1850	28	8
10	33	2100	31	8.5
11	37	2250	35.5	10.5
12	34	1850	32	10.5
13	32	2000	30	9
14	20	650	19	6
15	32	1900	29	11
16	28	1400	27.5	8
17	18	250	17	9
18	32	1850	29	10
19	38	2300	36	10.5
20	31	2050	28	7
21	24	1200	23.5	8
22	26	1300	27	7
23	29	1700	28	8
24	22	450	21	6
25	26	600	23	7.5
26	24	550	23	8
27	23	350	19	7
28	20	400	17	8
29	31	1950	29	8.5
30	20	350	18	6
31	33	2050	31	7.5
32	25	1000	24	6.5
33	31	1900	29	7
34	36	2200	34	10.5
35	38	2400	36	11
36	33	2100	31.5	8.5
37	37	2300	35	9
38	24	400	23	7
39	33	2150	31	8
40	27	1200	26	5.5
41	19	1300	17	7.5
42	34	2250	31	6
43	36	2400	34	10.5
44	38	2450	36	11
45	27	550	25	8.5
46	29	600	28	8
47	31	1850	28	10
48	35	1950	32	9
49	25	450	23	8
50	19	350	17	6

Table 1. Showing the Order of Collection of Foetuses

RESULTS

Total No. of Limbs	Normal	Variations
100	100	Nil

Table 2. Median Nerve Formation (50 Foetuses= 100 Limbs)

Total No. of Limbs	Normal	Variations
100	100	Nil

Table 3. Median Nerve Course (50 Foetuses= 100 Limbs)

Total No. of Limbs	Normal	Variations
100	100	Nil

Table 4. Median Nerve Termination (50 Foetuses= 100 Limbs)

Total No. of Limbs	Normal	Variations
100	97	3

Table 5. Median Nerve Branches (50 Foetuses= 100 Limbs)

Figure 1. Photograph Showing the Abnormal Communication (1) Between Musculocutaneous Nerve (2) and Median Nerve (3) in the Arm

Figure 2. Photograph Showing the Abnormal Communication (1) Between Median Nerve (2) Musculocutaneous Nerve (3) in the Arm

Figure 3. Abnormal Innervation of the Flexor Digiti Minimi Muscle of the Hypothenar Eminences by the Branch of the Median Nerve (1)

DISCUSSION

As early as 18th century, the nervous system in general and median nerve in particular has attracted many scientists to attempt and plan for a detailed study as this nerve was usually involved in occupational accidents. Variations in the muscular, cutaneous and terminal branches were taken into consideration leaving articular and vascular branches.

Harris W. (1904) found the formation of brachial plexus to be same as per the present standard textbook description. Kerr A. T. (1918) has studied extensively regarding the formation of brachial plexus in general and formation of median nerve in particular. He dissected 175 limbs in which he found 168 cases with lateral cord containing C4 to C7 fibres or C5 to C7 fibres. In rest of the cases, the lateral cord received a contribution from lower elements. He also studied the size of the lateral root of the median nerve and he clearly described a communication from musculocutaneous nerve to median nerve in the arm. One more important observation from Kerr's series was that in great majority of cases lateral root of the median nerve is derived from lateral cord. But in seven cases the lateral root of median nerve was derived from anterior division of upper trunk and then joined by 7th cervical fibres. In one case the lateral root of median nerve was derived from upper trunk with 7th cervical fibres joining medial root of median nerve and in another case lateral root of median nerve was derived from 7th cervical, ventral rami.

Kerr A. T. also studied the medial root of median nerve. Out of 175 specimens, almost in 170 specimens the medial root of median nerve was formed from medial cord and in rest of the cases there was no medial cord proper. Another important observation of Kerr A. T. (1918) is that the median nerve was formed by the fusion of two roots, one derived from lateral cord and the other from medial cord in 86.85% of cases. In the rest, it was derived in an abnormal manner. In the present study the formation of median nerve is correlating with other scientific workers observation, i.e., the formation of median nerve was by fusion of medial and lateral roots derived from the respective cords. There were no other communicating branches between the cords and roots in the present study.

Kerr A. T. (1918) found the anastomosis between median and musculocutaneous nerve in 10-24% of cases in his detailed study.

Le Minor[1] (1992) classified the communication between median nerve and musculocutaneous nerve into five types depending on levels of communications and number of fibres.

- Type 1. There is no communication between the median and musculocutaneous nerves
- Type 2. The fibres of medial root of median nerve pass through the musculocutaneous nerve and join the median nerve in the middle of the arm.
- Type 3. The lateral root or the medial root fibres of median nerve pass through the musculocutaneous nerve and after some distance leave it to form the root of the median nerve.
- Type 4. The musculocutaneous nerve fibres join the lateral root of the median nerve and after some distance the musculocutaneous nerve arises from the median nerve.
- Type 5. The musculocutaneous nerve is absent and the entire fibres of musculocutaneous nerve pass through lateral root and fibres to the muscles supplied by musculocutaneous nerve branch out directly from the median nerve.

Venieratos and Anagnostopoulous[2] (1988) opined that such communications between musculocutaneous nerve and median nerve is by far the most common and frequent finding of all the variations observed. They described another type of classification of communication between median nerve and musculocutaneous nerve i.e. in relation to coracobrachialis muscle.

- In type I - communication between musculocutaneous nerve and median nerve is proximal to the entrance of musculocutaneous nerve to coracobrachialis.
- In type II - the communication is distal to the muscle
- In type III - neither the nerve nor the communicating branch pierces the muscle.

Many scientists like Srinivasan R and Rhodes J[3] in 1981, Gumusburn E and Adiguzel E[4] in 2000, have described cases of communication between median nerve and musculocutaneous nerve. Choi D, Rodriguez- Niedenfuhr M, Vazquez T, Parkin I, Sanudo J. R[5] in 2002 expressed their opinion in their article titled "Patterns of connections between the musculocutaneous and median nerves in the axilla and arm". They studied 138 cadavers (66 Male and 72 Female). In 73 limbs of 64 cadavers i.e. in 46.4% of cases, a communication between median nerve and musculocutaneous nerve was found (9 bilaterally and 55 unilaterally). They did not observe any significant difference by gender or side of the limb. They classified these communications into 3 main patterns -

1. Fusion of both nerves (14 arms, 19.2%).
2. Presence of one supplementary branch between both nerves (53 arms, 72.6%).
3. Two branches (5 arms 6.8%).

In the present study the abnormal communication between musculocutaneous nerve and median nerve was seen in 2 out of 50 Foetuses. So, in the entire study, the abnormal communication between these nerves was seen in 2 out of 50 bodies i.e. about 4% occurrence.

In a study of 125 cases, Gruber[6] (1870) described a communicating branch between median nerve and ulnar nerve in 15% of limbs. Thompson I. M[7] (1922) described such connections in 15% of his study of 406 cases. Srinivasan R and Rhodes J in an article titled "The median and ulnar anastomosis in normal and congenitally abnormal Foetuses" in 1984 clearly mentioned the median - ulnar nerve anastomosis in the forearm in 15% of normal Foetuses. Among congenitally abnormal Foetuses, all the cases of trisomy - 21 had anastomosis in both forearms. Artico M, De Santis S[8] in the year 2000 evaluated the anatomy of median nerve and ulnar nerve in six fresh cadavers and they found median nerve and ulnar nerve anastomosis at various levels and concluded that these variations are not infrequent. Gumusburn E and Adiguzel E in 2000 reported such communication. In the present study in foetuses, no such communication was observed between median nerve and ulnar nerve in the entire course of the median nerve.

Though a number of scientists dissected and described in detail about median nerve, but none has reported any variation in its course in the arm. In the present study the course of median nerve was same as given in all the standard textbooks of anatomy. In 8.7% of cases of 300 specimens dissected by Jameson and Anson[9] (1930) the median nerve passed deep to pronator teres muscle, where ulnar head was absent. In 1952 the above scientist made another study and observed the course of median nerve to be in the above manner in 8.7% of the cases. Anson B. J[10] (1963) studied 1000 specimens. In 10.8% the median nerve coursed posterior to the humeral part of pronator teres as ulnar slip was absent. He also found the median nerve passing through humeral part of muscle in 1.8% of cases and the nerve passed posterior to both heads of the muscle in 4.6% of cases. In the present study of 50 Foetuses of various ages from 17 weeks to 36 weeks, the median nerve was passing in between the two heads of the pronator teres. Absence of the ulnar head of the muscle was not found in the present study. In all the limbs dissected the two heads of pronator teres could be identified clearly unlike the findings of other scientists.

Normally after passing through the carpal tunnel at the distal border of flexor retinaculum the median nerve divides into terminal branches. The branches are muscular branch to thenar muscles, a common digital branch to the thumb, proper digital branch to the radial side of index finger and 2 common digital nerves to the adjacent sides of index and middle fingers and middle and ring fingers respectively. According to Henry Hollinshead W[11] (1958) the exact level of branching varies. It may be beneath the distal border of flexor retinaculum or it may be in the proximal portion of the palm of the hand. Lanz[12] (1977) reported a high division of median nerve in 2.8% cases of 246 hands studied. In the present study median nerve divided into medial and lateral division beneath the distal border of flexor retinaculum which further divided into 5 - 6 branches as given in the standard text books.

The branches of median nerve are mostly muscular branches. Linelle E.A. (1921) noted a branch to pronator teres 1-2 cm below the level of the tip of lateral epicondyle of humerus. Sunderland S. and Ray L. J. (1946) reported a range in the origin of muscular branch to pronator teres from 7 cms above to 2.3 cms below the medial epicondyle of humerus. Out of study in 20 specimens, they found 1 branch to pronator teres in 6 specimens, 2 branches in 9 specimens, 3 branches in 4 specimens and 4 branches in 1 specimen. They also observed that the upper most of these nerves usually arise alone but other branches to this muscle frequently arise either by a common branch or along with the branches to other superficial flexor muscles of the forearm. They reported that anterior interosseous nerve which is the largest muscular branch of the median nerve arises from its posterior surface some 2-3 cm below the level of median epicondyle. In their study, the muscular branch to pronator teres was found arising above the level of epicondyles of humerus in 36 limbs. In 6 Foetuses (12 limbs) the branch was given off bilaterally above the level of epicondyles. In rest of the limbs it was found only unilaterally. There were mostly 2 branches to pronator teres, flexor carpi radialis and flexor digitorum superficialis. In the present study the following variations were found:

1. The musculocutaneous nerve arising from median nerve in the arm was observed in one specimen.
2. The median nerve giving rise to lateral cutaneous nerve of forearm was observed in another specimen.

In 1946 Sunderland and Ray found median nerve dividing into medial and lateral divisions in 78 limbs. The level of branching also varied from 16 - 19 mm from radial styloid process. In 1968 Papathassion[13] observed and reported that the muscular branch from the median nerve to thenar muscles arising in the carpal tunnel. In 1990 Seradge

and Seradge[14] observed the median nerve innervating the hypothenar muscles. In 1995 W. R. Saeed and D. M. Davis[15] observed sensory innervation of little finger by a communicating branch of median nerve just proximal to the wrist along with innervation of hypothenar muscles. In 1999 Boluk and Basi O et al[16] reported a case of ulnar nerve innervating both thenar and hypothenar muscles. According to Francisco Prado Reis et al[17] the frequency of variation in formation of the median nerve was 28%. The more frequent anatomical variations were: a communicant branch between the median and the musculocutaneous nerves (10%) and a lateral cord which gave rise to a couple of lateral branches to formation of the median nerve (8%). In the present study, one abnormal innervation by a muscular branch of the median nerve to the flexor digiti minimi muscle of hypothenar eminence was observed.

Sl. No.	Author's Name	Percentage of Variations
1.	Kerr AT	24
2.	Choi. D et al	46.4
3.	Dr. Krishna Chaitanya et al	2
4.	Present study	4

Table 6. Comparison of Percentages of Abnormal Communication Between Median Nerve and Musculocutaneous Nerve

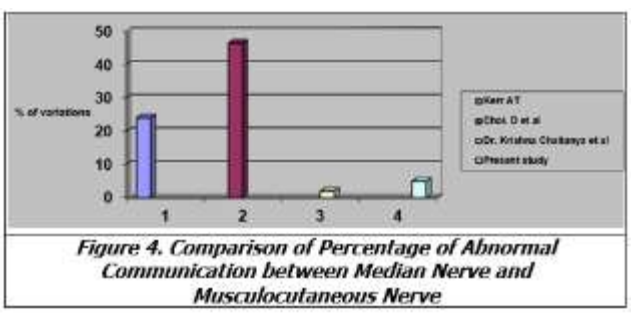

Figure 4. Comparison of Percentage of Abnormal Communication between Median Nerve and Musculocutaneous Nerve

CONCLUSIONS

Currently, hand reconstruction surgery is gaining importance. Of the 3 main nerves supplying the upper limb i.e., median nerve, ulnar nerve and radial nerve, the median nerve is frequently involved in most of the road accidents, occupational injuries, birth injuries, metabolic disorders, cancers etc. this importance of median nerve prompted me to study about the median nerve. In the present study, 50 foetuses at different stages of development were collected and fixed in formalin. All the upper limbs (100) were dissected and the median nerve was traced from its formation till termination. Though the median nerve has articular, vascular, cutaneous, muscular and digital branches, only cutaneous and muscular branches were considered and presented. Majority of the studies done by previous workers was in adults and very little literature is available regarding the median nerve in foetuses. The formation, course and termination of the median nerve in foetuses were found to be same as description given in the standard text book of anatomy. Among the branches of the median nerve, variations were observed in 3 limbs. In two foetal limbs, there was communication between the median nerve and the musculocutaneous nerve. In one foetal limb, there was abnormal innervation to the hypothenar muscle from the median nerve. So, in the entire study, the abnormal communication between the median nerve and the musculocutaneous nerve was seen in 2 out of 50 dead foetuses i.e. about 4% occurrence. A detailed knowledge of the median nerve with its variations helps surgeon to plan reconstructive surgery of hand in situations like crush injury, birth injury, malignancy, compression of median nerve in carpal tunnel which is now a frequent occurrence in computer professionals.

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