

Variations of the ventral rami of the brachial plexus

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We studied the variations in the ventral rami of 152 brachial plexuses in 77 Korean adults. Brachial plexus were composed mostly of the fifth, sixth, seventh and eighth cervical nerves and the first thoracic nerve (77.0%). In 21.7% of the cases examined, the fourth, fifth, sixth, seventh and eighth cervical and the first thoracic nerves contributed to the plexus. A plexus composed of the fourth, fifth, sixth, seventh and eighth cervical and the first and second thoracic nerves, and a plexus composed of the fifth, sixth, seventh eighth cervical nerves were also observed. The plexuses were classified into three groups according to cephalic limitation, and the plexus of group 2 in which the whole fifth cervical nerve enters the plexus, were observed the most frequent. The average diameter of the sixth and the seventh cervical ventral rami of the plexus was greatest and that of the fifth cervical was smallest. The largest nerve entering the plexus was the sixth or the seventh cervical nerve in about 79% of cases. The dorsal scapular nerve originated from the fifth cervical ventral ramus in 110 cases (75.8%). The long thoracic nerve was formed by joining of roots from the fifth, sixth, and seventh cervical nerves in 76.0% of cases. Also, a branch to the phrenic nerve, the suprascapular nerve, a nerve to the pectoralis major muscle and a nerve to the subscapular muscle arising from the ventral rami of the plexus were observed.

Key Words: *Brachial plexus, Long thoracic nerve, Dorsal scapular nerve, Korean*

INTRODUCTION

In western textbooks, there is a discription that some fibers from the fourth cervical nerve frequently join the formation of the brachial plexus (Gardner et al., 1975; Romanes, 1981; Clemente, 1985; Woodburne and Burkel, 1988). Kerr (1918) found that among 175 plexuses, 63% receive a fiber bundle from the fourth cervical nerve. But in Koreans, we found in our Anatomical laboratory that the brachial plexus usually composed of the fifth, sixth, seventh and eighth cervical nerves and the first thoracic nerve, with an infrequent

contribution of the fourth cervical nerve to the plexus. From this difference, we reconsidered the composition of the brachial plexus of Koreans. When the fourth cervical contribution is large and the first thoracic contribution small, the plexus is described as being prefixed in relation to the vertebral column. By contrast, when the contribution of the first and second thoracic nerves is large, the plexus is termed postfixed (Miller, 1934; Hollinshead, 1982). Therefore, we started to study the composition of the brachial plexus in Koreans, and compared the results with western report. Also by measuring the long diameter of the ventral rami of the plexus, we estimated the position of the largest nerve of the plexus.

Branches from the rami of the brachial plexus are usually known as the dorsal scapular nerve and the long thoracic nerve (Kerr, 1918; Hirasawa, 1931; Horwitz and Tocantins, 1938), but, its composition and

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variation have not been clarified. So, we also observed the nerve from the ventral rami of the plexus and its variation.

MATERIALS AND METHODS

This study was carried out in 152 (right side 76, left side 76) human brachial plexuses obtained from 77 dissection room cadavers from Anatomical laboratories of Yonsei University College of Medicine (74 cases) and Wonju College of Medicine (30 cases), Ewha Woman's University College of Medicine (19 cases), Soonchunhyang University College of Medicine (11 cases), Chonbuk National University College of Medicine (12 cases) and Chonnam National University Medical School (6 cases), during the years 1988 to 1991. Of the plexuses, 91 cases were from males, 61 cases were from females. Age range was 20 to 88 years.

The dissections were made in most cases by regular medical students under the careful supervision of the instructors. Variations in the formation of the brachial plexus were observed in all cases, and in 92 cases, the long diameter of the each ramus was measured with Vernier callipers. The branches arising from each ramus were observed.

RESULTS

In 117 plexuses (77.0%), the brachial plexus was formed by the ventral rami of the lower four cervical nerves and the first thoracic nerve. In 21.7% of cases, the fourth, fifth, sixth, seventh and eighth cervical and the first thoracic nerves contributed to the plexus. A

brachial plexus composed of the fourth to eighth cervical and the first and second thoracic nerves was present in one case. And in another case, a plexus composed of only cervical nerves (fifth to eighth) was observed. In females, the incidence of the fourth cervical nerve joining the brachial plexus was higher than in males (Table 1). The difference between the right side and the left side was not significant.

Brachial plexuses were classified into 3 groups; group 1, in which the plexus received a contribution from the fourth (22.4%), group 2, in which the plexus received the entire anterior primary division of the fifth cervical (63.8%) and group 3, in which a portion of the fifth cervical nerve contributed to the cervical plexus (13.8%). There was difference between males and females in the distribution among the three groups. Table 1 shows the difference of the distribution in Koreans and Americans among the groups according to sex.

The long diameter of the ventral ramus composing the brachial plexus was measured. The range was from 1.0 to 9.8 mm. Table 2 shows an average diameter of each ramus of the plexus. An average diameter of the ventral ramus of the left eighth cervical nerve of the male was greater than that of the female. There was no difference between the right side and the left side. The average diameter of the ventral ramus was equally greatest in the sixth and the seventh cervical nerve and smallest in the fifth cervical.

The largest nerve entering the plexus was the sixth or the seventh cervical nerve in about 70% of cases. The frequency of occurrence of the nerves with the greatest diameter is shown in Table 3 comparing the

Table 1. Distribution of the brachial plexus among three groups according to as sex and nationality.

	Korean Lee et al., 1991			American White Kerr, 1918			American Colored Kerr, 1918		
	Male %	Female %	Total %	Male %	Female %	Total %	Male %	Female %	Total %
	(91)	(61)	(152)	(65)	(20)	(85)	(49)	(41)	(90)
Group 1	20.9 (19)	24.6 (15)	22.4 (34)	63.0 (41)	75.0 (15)	65.9 (56)	57.2 (29)	60.9 (25)	60.0 (54)
Group 2	67.0 (61)	59.0 (36)	63.8 (97)	27.0 (18)	15.0 (3)	24.7 (21)	34.7 (17)	34.2 (14)	34.4 (31)
Group 3	12.1 (11)	16.4 (10)	13.8 (21)	9.2 (6)	10.0 (2)	9.4 (8)	6.1 (3)	4.9 (2)	5.6 (5)

Group 1: one in which a part of the fourth cervical nerve enters the plexus. Group 2: one in which the fourth cervical nerve does not enter the plexus but the whole fifth cervical nerve does. Group 3: one in which only a part of the fifth cervical nerve joins the plexus. Number of cases is given in parenthesis.

Table 2. Long diameter of each ramus of the brachial plexus.

	Right		Left		Both	
	Male (26)	Female (20)	Male (27)	Female (19)	Male (53)	Female (39)
C ₅	3.8±1.2	4.1±1.1	4.1±1.3	3.9±1.3	4.0±1.2	4.0±1.1
C ₆	5.5±1.4	5.4±1.3	5.8±1.4	5.2±1.0	5.6±1.5	5.3±1.1
C ₇	5.4±1.4	5.3±1.5	5.6±1.3	5.6±1.3	5.5±1.3	5.3±1.6
C ₈	5.2±1.0	4.8±1.7	5.3±1.0	4.4±1.5*	5.2±1.0	4.6±1.6*
T ₁	4.4±0.8	4.2±1.2	4.2±0.7	3.8±1.3	4.3±0.8	4.3±1.2

Unit: mm,

Mean±S.D.

* : p<0.05 comparing male with female: marked on female result

C₅: fifth cervical, C₆: sixth cervical, C₇: seventh cervical, C₈: eighth cervical, T₁: first thoracic ventral ramus, Number of cases is given in parenthesis.**Table 3.** Distribution of nerves with the greatest diameter in each group of the brachial plexus.

Nerve with the greatest diameter	Group 1 (26)	Group 2 (53)	Group 3 (13)	Total (92)
	%	%	%	%
Fifth cervical nerve	5.7	3.7	0.0	3.7
Sixth cervical nerve	42.9	28.0	29.4	32.1
Seventh cervical nerve	28.6	39.0	41.2	36.6
Eighth cervical nerve	11.4	25.6	23.5	21.6
First thoracic nerve	11.4	3.7	5.9	6.0
Total	100.0	100.0	100.0	100.0

Group 1: one in which a part of the fourth cervical nerve enters the plexus. Group 2: one in which the fourth cervical nerve does not enter the plexus but the whole fifth cervical nerve does. Group 3: one in which only a part of the fifth cervical nerve joins the plexus. Number of cases is given in parenthesis.

plexuses of each group. In group 1, the incidence of the sixth cervical being the greatest nerve was the most frequent, but in group 2 and 3, it was frequently the seventh cervical nerve.

Nerves originating from the ramus of the brachial plexus were the dorsal scapular nerve, the long thoracic nerve, a branch to the phrenic nerve, the suprascapular nerve, a nerve to the subclavian muscle and a branch to the pectoralis major muscle.

The dorsal scapular nerve was observed in 145 plexuses. The nerve originated from the fifth cervical ventral ramus in 110 cases (75.8%), of which, in 7 cases, it pierced the middle and posterior scalene muscle. In 13 cases (9.0%) it arose from the superior trunk of the plexus. In 11 cases (7.6%) it arose from the fourth and fifth cervical ventral rami, and in another 11 cases, the nerve originated from the sixth cervical ventral rami.

The long thoracic nerve was observed in 142 plexuses. The nerve being formed of the fifth, sixth and seventh cervical nerves was most frequently observed (75.3%), usually the first two root piercing the middle scalene muscle and the seventh passing in front of that muscle. In 16 cases (11.3%), the nerve was composed of the sixth and the seventh cervical nerves. In 11 cases (7.7%), the root from the seventh cervical nerve was missing. An additional root from the eighth cervical nerve was observed in 4 cases (2.8%), and that from the fourth nerve was observed in 1 case (0.7%). The long thoracic nerve was formed of the sixth, seventh and eighth cervical nerves in 3 cases (2.0%). Infrequently, the nerve did not pass through the middle scalene muscle and the nerve trunk was formed over the first rib. Sometimes the fifth cervical nerve did not join the main trunk of the nerve but passed directly to the upper digitation of the anterior scalene muscle.

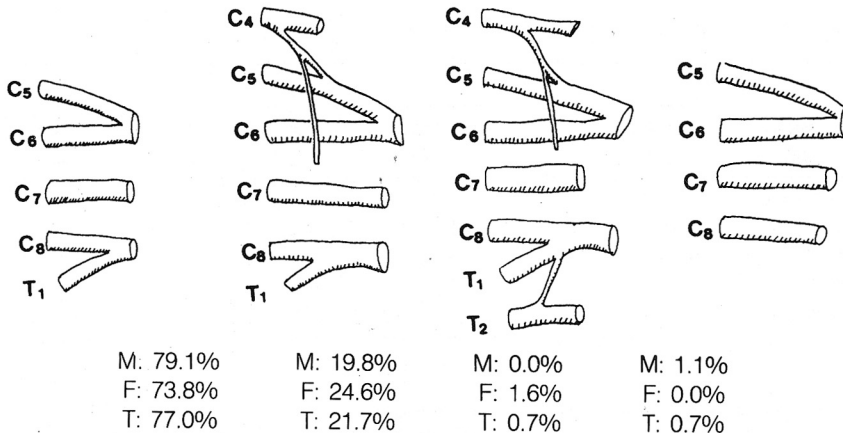


Fig. 1. Schematic representation composition of the brachial plexus and its distribution in Koreans. C₄: fourth cervical, C₅: fifth cervical, C₆: sixth cervical, C₇: seventh cervical, C₈: eighth cervical, T₁: first thoracic, T₂: second thoracic nerve. M: male, F: female, T: total.

At the ventral rami of the fifth cervical nerve, a branch to the phrenic nerve was observed in 15 cases, and a branch to the subclavius muscle was observed in 8 cases, and a suprascapular nerve originating from the fifth cervical ventral ramus was observed in one case. A branch to the suprascapular nerve arose from the sixth cervical ventral ramus in 2 cases. An additional root to the pectoralis major muscle arose from a common trunk formed by union of the sixth and seventh cervical nerves in one case.

DISCUSSION

Many anatomists have agreed that, in man, the ventral rami of the caudal cervical nerves and a part of the first thoracic nerve always enter into the formation of the brachial plexus and, some authors state that there is sometimes a fasciculus from the fourth cervical which joins the plexus or that in many cases such a branch is usually present (Paterson, 1896; Harris, 1904; Scott, 1906; Kerr, 1918; Miller and Detwiller, 1936). Kerr (1918) found among 175 plexuses that 62% receive a fiber bundle from the fourth cervical nerve. A filament from the second thoracic nerve is found not infrequently in many cases. Eckhard (1862), Kaufmann (1864), Cunningham (1877) and Adorphi (1898) have shown that the second thoracic nerve at times contributes to the brachial plexus. Cunningham (1877) found the second thoracic nerve joining the first in 27 out of 37 cases and it may be single, double or triple. When double, usually one twig joins the intercostal and one the brachial branch of the first thoracic nerve. Harman

(1900) found the connection in 7 out of 12 dissections. Paterson (1896) found the connection in only 11 out of 33 cases. Harris (1904) states that it is only in the postfixed types, in which it might be expected that the second thoracic nerve will join the first and thus contribute to the plexus. In this report, the cephalic limits of the plexus are noted in about one fifth (21.5%) of instances and the caudal limits were found in only one instance. So there is a difference in compositional variations of the brachial plexus according to races.

Kerr (1918) classified the plexus, according to the spinal nerve forming the plexus, into 3 groups. He designated group 1 as one in which a branch from the fourth cervical nerve entered the plexus and 62.85% of his cases fell into this group. Group 2 was another group of plexuses in which the whole of the fifth cervical nerve enters the plexus without any additions from the fourth cervical. He found 29.71% of the cases could be included in group 2. In group 3, no part of the fourth cervical nerve entered the plexus and also, the plexus did not receive the whole of the fifth cervical nerve. 7.43% of the cases in his study were included in this group. But in Koreans, this was reversed, that is, the brachial plexus of group 2 was more frequent (64.2%) than that of group 1. In females, the incidence of the fourth cervical nerve joining the brachial plexus was higher than in males. The tendency of the plexus in the female to be more cephalic in position than that of the male was observed similarly in Koreans and in Americans (Table 1). In Americans, plexuses of groups 1 and 3 occur more often in white, and of group 2 in colored subjects.

The brachial plexus has been classified as cephalic and caudal, high and low, or prefixed and postfixed (Kaufman, 1864; Adorphi, 1898; Harris, 1903). The classification of the plexus into cephalic and caudal is usually based upon the position of the plexus along the body axis. Those plexuses that receive branches from the fourth cervical nerve would be more cephalic than those that do not. According to Kerr (1918), the plexuses of group 1, in which a branch from the fourth cervical nerve joins the plexus may be classified as cephalic, while those of group 3 in which the fifth cervical nerve sends a branch to the cervical plexus can be classified as caudal, while those of group 2 in which the fifth neither receives nor gives off a branch would be classified as intermediate. The terms, especially 'prefixed' or 'postfixed', have been used to indicate the estimated position of the greatest strength of the plexus, that is, the position of the largest nerves (Harris, 1903). Kerr (1918) decided the portion of the largest nerve by measuring the diameter, and correlating this with the division of the plexuses into groups. And he found that even in the plexus which was classed as cephalic because of receiving a branch from the fourth cervical nerve, the largest nerve was variable, thus leading him to state that each group would have to be subdivided into prefixed, postfixed and intermediate. For example, even in a plexus of group 1, he classified those cases in which the largest nerve was the eighth or the seventh and eighth as postfixed, and only those cases in which the largest nerve was the eighth or the seventh and eighth as postfixed, and only those cases in which the largest nerve was the sixth and possibly the seventh as prefixed. In this report, definite prefixed type was presented in 48.6% of plexuses in group 1, and definite postfixed type was present in about 29% of plexuses in group 2 and group 3. In Americans, the greatest nerve entering the plexus was the seventh or the eighth in over 70% and the cephalic type plexus (group 1) was present in 63%. But in Koreans the greatest nerve was the sixth or the seventh in about 70% and the cephalic type plexus was 21.5%. Therefore even the brachial plexus of Koreans is more caudal in position than that of Americans, and additionally plexuses of the prefixed type are more frequent in Koreans.

The dorsal scapular nerve usually arose directly from the ventral ramus of the fifth cervical and contained only fibers from this nerve. According to Kerr (1918), it arose with the nerve to the subclavius in three among 83 sides, and the common stem of the nerve arose from the trunk formed by the union of the fourth and fifth cervical nerves instead of directly from the fifth cervical. In 11 cases, we found the common

stem of the dorsal scapular nerve forming by the union of the dorsal scapular nerve forming by the union of the fourth and fifth cervical nerves but it did not rise with the nerve to the subclavius. Horwitz and Tocantins (1938) found that the nerve arose with the contribution of the fifth cervical nerve to the long thoracic nerve in 44%, but we did not observe this. Instead, we found another variation similar to this in which the dorsal scapular nerve arose directly from the sixth nerve.

The long thoracic nerve formed as usual by joining of roots from the fifth, sixth, and seventh cervical nerves in 76.0%. Horwitz and Tocantins (1938) reported that the seventh cervical nerve failed to contribute to the nerve in a similar frequency (8%) to that (7.3%) of this report, and fibers from the eighth cervical joined those from the fifth, sixth and seventh cervical in a higher frequency (8%) than is reported here. Even though they found no example in which the fifth cervical failed to contribute at all, we found this situation in 3 cases (2.0%). Additionally we found varying relations of the long thoracic nerve to the middle scalene muscle.

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