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Arteries of the Forearm in the *Macacus cyclopsis*

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Gross anatomical and statistical studies were done in order to determine the standard condition (normal form) of the course and distribution of the arteries in the forearm of Formosan macaques, and furthermore compared with the finding for man and other primates.

A study to determine the normal condition of the various organ systems of the *Macacus cyclopsis* is in progress in the department to which I belong using a large number of *Macacus cyclopsis* as material. Previously, Yoshimi*13*) reported on the investigation of the arteries of the upper arm, while Mori*9*) presented a paper on the arteries of the hand which had been done as a part of this study. I have conducted the investigation of the arteries of the forearm and the results are presented in this report.

As mentioned by Yoshimi and Mori, many reports have been published on the arteries of primates, but in these investigations the number of cases of each species which had been studied was very small, and consequently when individual variations are considered, their results can not immediately be accepted as indicating the normal condition in that animal. This present study not only concerns the normal condition of *Macacus cyclopsis* but also can be considered to represent the typical condition in the macaques.

MATERIAL AND METHOD

The material consisted of both arms of 50 adult *Macacus cyclopsis* (31 male, 19 female) selected from among the specimen preserved in this department which had been collected by Professor SATOH. These specimens had been fixed by injecting 10% formalin solution into the femoral artery immediately after capture and strangulation. Dye had been injected into the blood vessels to facilitate observation in some of the cases.

A so-called gross anatomical study had been done with a dissecting knife and tweezers with the aid of binocular magnification lenses.

FINDING AND CONSIDERATIONS

The A. brachialis in the *Macacus cyclopsis* usually gives off the A. brachialis superficialis in the middle part of the upper arm. This branch, the A. brachialis superficialis, which runs in the superficial layer, is larger than the main trunk and runs in front of the N. medianus lateraward to the forearm where it becomes the A. radialis. In the middle part of the forearm, it separates into the Ramus anterior, which
runs to the palm where it forms the Arcus palmaris superficialis, and the R. posterior, which supplies the dorsum of the hand.

On the other hand, the A. brachialis, after giving off the A. brachialis superficialis, further divides at the upper forearm into the A. ulnaris and the A. interossea commu-

nins. The former gives off a small number of Rr. musculares and Rr. articulares as it runs to the palm where it contributes to the formation of the Arcus palmaris superfi-

cialis from the ulnar side. The latter further divides into the A. mediana, the A. interossea anterior and the A. interossea posterior which supply the various muscles of

the forearm.

Consequently, the arteries supplying the forearm include the A. radialis, the A. ulnaris, the Aa. interosseae, the A. mediana and the small branches from these arteries.

1. A. radialis

The A. brachialis superficialis, after separating from the A. brachialis at the middle of the upper arm, gives rise at the elbow to many Rr. musculares, Rr. articulares and the A. recurrens radialis. It then becomes the A. radialis which runs along the radial side of the forearm.

The A. radialis runs beneath the biceps fascia and gradually emerges into the superficial layer. It runs along the radial side of the forearm toward the wrist, but at the middle of the forearm it separates into the R. anterior and R. posterior.

The R. anterior becomes the R. palmaris superficialis which continues downward to the palm where it joins with the terminal branch of the A. ulnaris from the ulnar side to form the Arcus palmaris superficialis. On the other hand, the R. posterior even after separating from the R. anterior runs almost parallel with the R. anterior toward the wrist, but when it reaches the lower edge of the Proc. styloideus of the Radius, it changes its direction toward the dorsum of the hand and, after giving rise to the R. carpius dorsalis, becomes the artery of the dorsum of the hand.

The point of bifurcation of the A. brachialis superficialis in primates is different according to the family, ranging from the elbow to the axilla. This is because some of the anastomosing branches between the arteries corresponding to the A. brachialis superficialis and the A. brachialis profunda are large while others have secondarily disappeared.

The A. radialis in most cercopithecidae is a condition in which the upper part of the A. brachialis superficialis has disappeared and corresponds to the A. brachialis superficialis inferior of Z. Müller and is essentially different from the A. radialis in man (Manners-Smith, etc.). Also, the high origin of the A. radialis, which occurs in rare cases in man, is a condition that is different from the intrinsic A. radialis of man and in most instances it is considered to be the atavic variety due to the reappearance of the proximal part of the A. brachialis superficialis.

Consequently, comparison of the height of the bifurcation of the A. radialis in my cases of Macacus cyclopes and in man is meaningless and was not attempted.

The state of the A. brachialis superficialis and the A. brachialis profunda in the upper arm has previously been described in the paper by Yoshimi of this department while the state of the terminal branches in the dorsum and palm of the hand has been presented in the report of Mori. Therefore, they will not be discussed here.

Manners-Smith has noted superficial vessels, the Aa. antebrachii superficialis voralis (Müller), which are given off from the lower part of the A. brachialis superficialis, in Prosimiae and many other primates, but this artery could not be
Fig. 1. A. radialis
(Right forearm, anteromedial view)

1. M. biceps brachii
2. M. triceps brachii
3. M. brachioradialis
4. M. pronator teres
5. M. flexor carpi radialis
6. M. flexor carpi ulnaris
Fig. 2. A. ulnaris
(Right forearm, anteromedial view)

1 M. biceps brachii
2 M. triceps brachii
3 M. brachioradialis
4 M. pronator teres
5 M. flexor carpi radialis
6 M. flexor carpi ulnaris
7 M. flexor digitorum superficialis
8 M. flexor digitorum profundus
A. brachialis superficialis

2. A. ulnaris

The A. brachialis, after giving off the A. brachialis superficialis, passes the elbow to the forearm where it separates into the A. ulnaris and the A. interossea communis, but prior to this division it usually gives rise to the A. recurrens ulnaris.

The separation of the A. ulnaris and the A. interossea communis takes place at the cubital fossa just as in other primates, but the level of this bifurcation in relation to the length of the forearm in most cases (56%) is at a point in the upper fourth to upper fifth of the forearm, and in other cases the bifurcation is higher up near the humeroradial joint.

The A. ulnaris, after separating from the A. interossea communis, sinks beneath the M. flexor carpi radialis and runs toward the distal forearm. As it runs along the ulnar side to the palm, it gives off a few Rr. musculares and Rr. articularis, but the R. posterior is sent off first in the proximal part. This R. posterior a. ulnaris passes below the Proc. styloideus of the ulna to the dorsum of the hand and in addition to supplying the ulnar side of the dorsum of the hand, it unites with the R. posterior a. radialis to form the so-called Catella.

On the other hand, the A. ulnaris, after giving off the R. posterior, continues its descent to the wrist where it runs to the palmar side and at the medial side of the Os pisiforme, gives rise to the R. palmaris profundus which runs to the deep part of the palm to form the Arcus palmaris profundus. This artery continues downward and finally becomes the A. marginalis palmaris uln. which supplies the ulnar edge and further curves radialward to form the Arcus palmaris superficialis.
after uniting with the A. radialis (R. palmaris superficialis).

3. **A. recurrens ulnaris**

The A. recurrens ulnaris is given off from the A. brachialis after it passes the cubital fossa, immediately before its separation into the A. ulnaris and the A. interossea communis, that is at the area of insertion of the M. flexor carpi radialis and runs laterally between the M. flexor digitorum profundus and the M. flexor carpi radialis, but soon separates into the R. anterior, which passes along the lower surface of the N. ulnaris, and the R. posterior, which runs along the upper surface. Both of these branches supply the Olecranon.

This artery arises directly from the A. brachialis (prof.) in the majority of cases (55.0%). This was followed in frequency by origin from the region of the bifurcation of the A. ulnaris and the A. interossea communis (37.0%), but cases in which it arises from the A. ulnaris is rare (8.0%) while there was no case in which it is sent off from the A. interossea communis. The study of the relationship of the origin of this artery in other primates by MANNERS-SMITH shows that among Cebidae, first the R. anterior and then the R. posterior are given off independently from the A. brachialis prior to the separation into the A. ulnaris and the A. interossea communis in Ateles, Lagothrix, etc. Among Cercopithecidae, the R. posterior which was present in all cases is directly sent off from the A. brachialis, but in Macacus cynopithecus, cercopithecus, etc., the R. anterior is absent while in semnopithecus, cercocebus and cynomorphen, the R. anterior is present and directly given off from the A. brachialis. Also, among Simidae, in particular gorilla, orang and chimpanzee, this artery is said to arise from the A. ulnaris and the site of origin is the same as in my cases of Macacus cyclopsis except for the fact that there is no mention of origin of the R. anterior and R. posterior by a common trunk from which the separation occurs later as in my cases of Macacus cyclopsis. In man, it is said to sometimes arise from the A. radialis or the A. interossea communis. (MORI, ADACHI).

4. **A. interossea communis**

The A. interossea communis, after separating from the A. ulnaris at the cubital fossa, gives off the A. mediana and then divides into the A. interossea posterior and the A. interossea anterior which supply the muscles of the forearm. Usually, the A. interossea recurrens arises from the A. interossea posterior, but in very rare cases it is directly given off independently from the A. interossea communis (1%). In man, the A. interossea recurrens is said to usually arise from the A. interossea posterior.

5. **A. mediana**

This artery is poorly developed and only supplies a part of the muscles of the forearm. It extended as far as the palm in none of the cases, but MORI in his investigation of the Macacus cyclopsis reports one case (1%) in which the A. mediana was well developed and extended to the palm where it joined the Arcus palmaris superficialis.

The study of the relationship of the origin of this artery showed that in most cases (76.0%) it arises from the A. interossea communis, followed in frequency by origin from the region of the bifurcation of the A. interossea posterior and A. interossea anterior (23.0%) while in the remaining one case (1.0%) the origin was from the A. interossea anterior.

In the study of other primates, this artery has been found to arise directly from
the A. brachialis in *Cebus* and from the A. interossea communis in *Lagothrix*. Among *Cercopithecidae*, the A. brachialis, after giving off the A. ulnaris, separates into the A. interossea and the A. mediana in *Macacus sinicus*, while in *Cercopithecus*, *Calitrichus* and *Macacus rhesus* it arises from the A. interossea anterior and in *Cynocephalus babuin* it originates from the A. brachialis superficialis (MÜLLER, MANNERS-SMITH). In *Simidae*, it directly originates from the A. brachialis in the upper arm (MÜLLER), but in man it usually arises in the forearm though there apparently are racial differences (ADACHI).

6. Size of different arteries in the forearm

Of the arteries of the forearm, comparison between the A. radialis and the A. ulnaris at the middle of the forearm shows the A. radialis to be always larger than the A. ulnaris. In comparison of the A. radialis with the A. interossea communis and the A. radialis is larger in most cases (67%), the two are about equal in size in a considerable number of cases (31%), while it is very rare for the A. interossea communis to be larger (2%). In comparison of the A. interossea communis with the A. ulnaris and the A. interossea communis is almost always larger (82%) and the A. ulnaris was larger in none of the cases. With regard to the A. ulnaris and A. mediana, the A. ulnaris is larger in a comparatively large number of cases (59%), and there was no difference in size in other cases. The relation between the A. ulnaris and the A. interossea anterior shows that the frequency of cases in which the A. ulnaris is larger (51%) and that in which these two are equal in size (45%) are about the same. When the A. interossea anterior is compared with the A. interossea posterior, the A. interossea anterior is larger in a comparatively large number of cases (55%), while the A. interossea posterior was larger in a small number of cases (6%). Consequently, the following relation was noted in the size of the various arteries: A. radialis > A. interossea communis > A. ulnaris > A. mediana. Furthermore, this finding is very similar to the results for *Macacus rhesus* (MANNERS-SMITH) and *Macacus sinicus* (MÜLLER).

According to investigation in the past, the main blood vessel in the forearm, from the standpoint of phylogeny, is the A. interossea. In particular the A. interossea anterior gains importance for the first time in the forearm, while the A. radialis, A. ulnaris, A. mediana, etc., are formed secondarily. The relation A. radialis < A. ulnaris in *Prosimiae* usually is A. radialis > A. ulnaris or A. radialis = A. ulnaris in *Platyrrhinae* and *Catarrhinae*, but in *Simidae* the relation becomes A. radialis < A. ulnaris. MANNERS-SMITH has said that the increase in the size of the A. ulnaris may be possibly related to the action of pronation and supination as well as the abandonment of the quadrupedal position. In either case, atrophy of the A. interossea anterior, the A. interossea posterior and the A. mediana was seen in my cases of *Macacus cyclopis*, but this has not progressed to the point that the A. ulnaris is larger than the A. interossea and it is noteworthy that the A. radialis plays the main role in the forearm.

**SUMMARY**

The course and distribution of arteries in the forearm of the *Macacus cyclopis* was investigated on both arms of 50 cadavers. The following results were obtained.

The A. brachialis gives off the A. brachialis superficialis at about the middle of
the upper arm, but this branch is larger than the main trunk after this separation. The A. brachialis superficialis runs to the forearm where it becomes the A. radialis and at the middle of the forearm divides into the R. anterior, which supplies the palm, and the R. posterior, which runs to the dorsum of the hand. On the other hand, the A. brachialis after giving off the A. brachialis superficialis separates into the A. ulnaris and the A. interossea communis at the upper part of the forearm. The A. ulnaris sends off Rr. musculares and Rr. articulares as it runs to the palm where it contributes to the formation of the Arcus palmaris superficialis. The A. interossea communis further separates into the A. mediana, A. interossea anterior and the A. interossea posterior.

1) A. radialis. The A. brachialis superficialis runs beneath the biceps fascia and emerges into the superficial layer to become the A. radialis which runs along the radial side of the forearm. At the middle of the forearm, it divides into the R. anterior and R. posterior. During its course it gives rise to Rr. musculares, Rr. articulares and the A. recurrens radialis. The R. anterior unites with the terminal end of the A. ulnaris on the palm to form the Arcus palmaris superficialis while the R. posterior which descends parallel with the R. anterior changes its course toward the dorsum of the hand at the Proc. styloideus radius to become the artery of the dorsum of the hand.

2) A. ulnaris. The A. brachialis (prof.) separates into the A. ulnaris and the A. interossea communis at the upper part of the forearm, but just before this bifurcation, it gives rise to the A. recurrens ulnaris. The A. ulnaris sends off Rr. musculares and Rr. articulares and at near the wrist gives rise to the R. posterior, which supplies the ulnar side of the dorsum of the hand, but the main trunk continues to the palm where it contributes to the formation of the Arcus palmaris profundus.

3) A. interossea communis. This artery is further divided into the A. mediana, the A. interossea anterior and the A. interossea posterior. From the A. interossea posterior, the A. interossea recurrens is sent off. The A. mediana is poorly developed and very rarely reached as far as the palm.

4) A. recurrens ulnaris. This artery most frequently is directly sent off from the A. brachialis before its separation into the A. ulnaris and the A. interossea communis. It separates into the R. anterior, which runs beneath the N. ulnaris, and the R. posterior, which runs above this nerve. Both of these branches supply the Olecranon.

5) When the size of various arteries of the forearm is compared, the following relation is noted: A. radialis > A. interossea communis > A. ulnaris > A. mediana.

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