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The Mm. prevertebrale in Formosan Monkey

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The prevertebral muscle group in Formosan monkey is composed of the four muscles, in other words, the M. longus capitis, M. longus colli, M. rectus capitis lateralis and the M. rectus capitis anterior. The author, after the inspection about these muscles from the standpoint of macroscopic anatomy, comparative anatomy and, furthermore, statistic consideration, recognized that there is considerable difference from the traditional observation of rhesus monkey which belongs to the same genus as Formosan monkey. However, it is supposed that this might be a mistake due to the small number of cases in traditional inspection of rhesus monkey.

INTRODUCTION

The muscles of the neck may be grossly classified into the superficial and deep groups. The former may be further subdivided into the superficial medial cervical muscles and the superficial lateral cervical muscles while the latter may be separated into the deep medial cervical muscles (prevertebral group) and the deep lateral cervical muscles (scalenes group). Of the muscles in the deep group, this report deals with the prevertebral muscle group which is composed of the M. longus capitis, M. longus colli, M. rectus capitis lateralis and the M. rectus capitis anterior.

The material of study consisted of 25 adult Formosan monkeys (Macaca cyclopis) selected at random from among the collection of Prof. SATOH. These animals immediately after capture and strangulation had been fixed by the injection of 10% formalin solution into the A. femoralis and preserved in this solution of same concentration. Inspection had been done in all cases with the use of magnifying lenses with an illumination attachment designed for dissection purposes in order to avoid overlooking any minute detail.
FINDINGS AND CONSIDERATION

1. M. longus capitis (Fig. 1, 2, 3)

This muscle arises from the anterior tubercles of the transverse processes of the third to sixth cervical vertebrae. The origin of this muscle is by muscle with an admixture of tendon. In particular, the origin of the portions arising from the fourth and fifth cervical vertebrae is composed almost entirely of tendon with only a small amount of muscle fiber and the two immediately unite to form a single muscle bundle which appears to be digastric in form. In contrast to this, the portions, which arise from the transverse processes of the third and sixth cervical vertebrae, are monogastric in form, respectively.

These three muscle bundles run upward and fuse into a single belly which inserts by muscle into the basilar portion of the occipital bone immediately rostral to the insertion of the M. rectus capitis anterior. The insertion takes place into a considerably extensive area. The insertion of the fasciculi from the third cervical vertebra is into the mediodorsal area while the insertion of those fasciculi which have lower origin successively become lateroventral.

The fasciculi which arise from the third and sixth cervical vertebrae are particularly large and the fasciculi which arise from the fourth and fifth vertebrae, as mentioned above, usually unite to form a single muscle bundle so that as a whole the shape of this muscle frequently takes the form of three heads (three fasciculi) (29 sides, 58%). On the other hand, the fasciculi from the fourth and fifth cervical vertebrae may unite with either the fasciculi from the third cervical vertebra or the muscle bundle from the sixth cervical vertebra so as to form two heads in a comparatively large number of cases (21 sides, 42%).

Because the fasciculi from the upper cervical vertebrae are located in the deeper layer, the muscle bundle from the sixth cervical vertebra which is in the most outer layer appears to cover the others. Furthermore, the muscle bundle which arises from the sixth cervical vertebra has a considerably powerful aponeurosis and at about the level of the second cervical vertebra, where it decreases in width but increases in thickness, there occurs a decrease in muscle fibers so that it becomes almost entirely tendinous because of which the muscle bundle appears to become digastric.

Nerve supply: This muscle receives short branches from the anterior rami of the first to fifth cervical nerves, but the second and third cervical nerves in particular always contribute.

The origin of this muscle in Prosimiae, according to Murie, is from the transverse processes of the second to sixth cervical vertebrae in Lemur catta, from the transverse processes of the third to sixth cervical
vertebrae in Lemur xanthomystax and from the first to seventh cervical vertebrae in Galago allenii with no case extending to the thoracic vertebra. On the other hand, he reports that origin extending down as low as the thoracic vertebra was noted in Galago crassicandatrio in which it extended to the fourth thoracic vertebra and in Loris gracilis and Nycticebus tardigradus in which it extended to the sixth thoracic vertebra or even lower. In other reports, the origin in some cases of Nycticebus tardigradus has been found to extend to the sixth thoracic vertebra (Mivart) while in Chiromys madagascarensis the origin may be the third thoracic vertebra (Murie, Eisler) or even the fourth thoracic vertebra (Zuckerkandle).

Although there are few reports on platyrrhine monkey and catarrhine monkey, the origin among platyrrhine monkey is reported to be the fourth to sixth cervical vertebrae or even the seventh cervical vertebra in Hapale jacchus (Beattie) and similar findings have been reported for Hapalides (Hill). The origin among catarrhine monkey is said to be the third to sixth cervical vertebrae in Macaca rhesus (Howell & Straus) and from the anterior tubercles of the transverse processes of the second to sixth cervical vertebrae in Semnopithesinae (Eisler) which is not very different from my findings for Macaca cyclopis.

Among anthropoid ape, the origin is from the second to sixth cervical vertebrae in Hylobates (Eisler) while in Gorilla it may be from the third to sixth cervical vertebrae (Raven, Duvernoy) or from the fourth to seventh cervical vertebrae (Eisler). In chimpanzee, the origin may be from the third to sixth cervical vertebrae (Sonntag, Gratiolet) or from the fourth cervical vertebra to the first thoracic vertebra (Stewart) whereas in Orang it is reported to be from the third to seventh cervical vertebrae (Stewart).

Thus, there is no definite difference on comparison between the various suborder, but it is suspected that the area of origin may perhaps tend to be more extensive and extend farther down in lower monkey.

With respect to the insertion, it is reported that in Nycticebus tardigradus one portion may separate to attach to the axis or the transverse process of some other cervical vertebra (Mivart), while in Chiromys madagascarensis one division may insert into the Bulla tympanica (Zuckerkandle) and in Hylobates there may be two insertions side by side into the occipital bone (Kohlbrügge), but in most instances the insertion is into the basilar region of the occipital bone with hardly any variation.

2. M. longus colli (Fig. 1, 2, 3)

This is a comparatively well developed muscle and it is possible to separate it into the supralateral, medial and infralateral portions. However, there is marked interdigitation of muscle fiber and fusion
Fig. 1
between these parts so that a definite separation cannot be made.

In general, the fasciculi which form the supralateral portion arise from the transverse processes of the third to sixth cervical vertebrae and usually insert into the anterior tubercle of the atlas and the axis or occasionally into the medioventral part of the third and fourth cervical vertebrae. The fasciculi forming the infralateral portion
arise from the anterior surface of the third and fourth or fifth thoracic vertebrae and converge to the transverse processes of the sixth to seventh cervical vertebrae. The other fasciculi which are located on the medical side and extend between the third and seventh cervical
vertebrae form the medial portion. Thus, both the origin and insertion may be separated into 3 areas (3 origins and 3 insertions).

However, there is marked fusion or interdigitation of muscle fibers between the medial, supralateral and infralateral portions so that they are not well demarked. Therefore, it may be possible to consider the medial portion to be the transitional part between the supralateral and infralateral portions or to be a part of the infralateral portion itself and to make a gross division into the upper (cervical) and lower (thoracic) fasciculi using the level of about the fifth or sixth cervical vertebra as the dividing point.

In other words, the upper (cervical) fasciculi arise by muscle with an admixture of tendon from the anterior tubercle of the transverse processes of the third to sixth cervical vertebrae medial to the origin of the M. longus capitis (98%). The origin is relatively stable but in rare cases the origin from the third and fourth cervical vertebrae may be absent so that the origin is from only the fifth to sixth cervical vertebrae (1 side, 2%).

These fasciculi insert by muscle into the anterior tubercle of the first cervical vertebra and the medial part of the anterior surface of the body of the second to fourth cervical vertebrae. The area of insertion is quite variable and although it involves the first to fourth cervical vertebrae in most instances (32 sides, 64%), there are some cases in which the insertion is the first to third cervical vertebrae (12 sides, 24%), the first to fifth cervical vertebrae (4 sides, 8%) or the first to sixth cervical vertebrae (2 sides, 4%).

On the other hand, the origin of the lower (thoracic) fasciculi is from the fourth cervical vertebra to fifth thoracic vertebra and both the upper and lower limits of origin are quite variable as compared with the upper fasciculi, but most frequently the origin is from the anterior surface of the body of the sixth cervical vertebra to the fourth thoracic vertebra. In particular, the muscle with the lowest origin is the largest and arises by tendon of considerable width. In other parts, there is admixture of muscle and tendon at the origin.

Moreover, these fasciculi converge toward the upper lateral side and insert most frequently into the anterior tubercle of the transverse process of the sixth cervical vertebra (41 sides, 82%), but occasionally the insertion may involve a greater area and insert by muscle with admixture of tendon into the anterior tubercle of the transverse processes of the sixth and seventh cervical vertebrae (9 sides, 18%).

Therefore, as a whole, this muscle has two origins, the body of the vertebra and the transverse process of the vertebra. It likewise has two insertions, the process of the vertebra and the body of the vertebra. In other words, it is possible to consider it to have double origin and double insertion.

Nerve supply: This muscle receives short branches from the second
to eighth cervical nerves, but it is very seldom that it is innervated
by a short branch from C₂ (4%) and the contribution by C₈ also is
comparatively infrequent (20%). It most frequently is supplied by the
third to seventh cervical nerves. Moreover, the upper cervical nerves
from the fifth and above seem to supply the part corresponding to the
supralateral portion of this muscle while the cervical nerves from the
sixth and below apparently send branches to the area corresponding to
the medial and infralateral portions.

There apparently is little difference from prosimian to anthropoid
ape in the relation of the upper and lower limits of this muscle to the
dorsal spine.

In other words, the lower limit is the fifth thoracic vertebra in
Lemur (Murie), the fourth thoracic vertebra in Loris (Murie), Nycticebus
(Murie, Mivart), Perodicticus (Murie), and Macaca rhesus
(Howell & Strauss), while it is the second or third thoracic vertebra
in Hapale (Beattie) and the fourth thoracic vertebra in Semnopithecus
(Eisler), Hylobates (Kohlbrügge), Orang (Stewart, Eisler) and
Chimpanzee (Sonntag, Gratiolet). These findings are not much differ-
ent from my findings for Macaca cyclopis and the difference by
species, genus, suborder, etc., in other words the difference between
higher and lower monkeys is not marked.

Moreover, in view of the fact that for Chiromys, Murie reports
the lower limit to be the third thoracic vertebra whereas it is the fifth
thoracic vertebra according to Zuckerkandle, there apparently is
variation of about 2 or 3 vertebral bodies in the lower limit according
to the individual case even within the same species.

The upper limit is the atlas in all primates except in the report
by Murie concerning Galago crassicaudatus in which the superior
oblique portion was found to insert by muscle into the basilar portion
of the occipital bone behind the M. rectus capitis major.

This muscle in many prosimian is reported to consist of three
portions, in other words, the inferior oblique, superior oblique and
vertical portions such as in man (Eisler) while in other reports it is
said to finally separate into three portions beginning from higher
primates (Beattie).

In a review of literature, definite division into three portions has
been noted in such Prosimiae as Galago, Perodicticus, Chiromys
(Murie) and Tarsius (Woollard, Hill), in such platyrrhine monkey
as Hapalidea (Hill) and Hapale jacchus (Beattie), and in such
anthropoid apes as Chimpanzee (Sonntag, Stewart). In contrast to
this, division into three portions is reported to be indefinite in such
Prosimiae as Lemur, Loris, Nycticebus and Tarsius (Murie), in such
catarrhine monkey as Macaca rhesus (Howell & Strauss) and in such
anthropoid apes as Orang (Stewart) and Gorilla (Raven).
Thus, there apparently is no definite relation between whether the animal is a higher monkey and whether there is definite division into three portions.

However, in a general review of the condition of origin and insertion, it seems that a gross classification of this muscle into the following 4 types is possible in primates.

In type I, of the three divisions, the fasciculi corresponding to the superior oblique portion, in other words, that part arising from the transverse process of the cervical vertebra is absent.

For example, Loris, Nycticebus (MURIE) would belong to this category in which this muscle arises from the anterior surface of the body of the first to fourth thoracic vertebrae and inserts into the body and the transverse process of the respective cervical vertebrae. Therefore, there is one origin and double insertion. (Fig. 4-1)

\[ \text{Vertebral body} \quad \text{Vertebral body} \quad \text{Transverse process} \]

In type II, the fasciculi corresponding to the inferior oblique portion is absent. Lemur, Tarsius (MURIE) and Macaca rhesus (HOWELL & STRAUS) belong to this category.

In this type, in addition to the portion with origin from the area extending from the lower cervical vertebrae to the upper thoracic vertebrae, there is a second origin from the transverse processes of the third to fifth (or sixth) cervical vertebrae. These fasciculi insert into only the anterior surface of the body of the first and lower

\[ \text{Type I} \quad \text{Type II} \quad \text{Type II} \]

**Fig. 4**
cervical vertebrae. There is no insertion into the transverse processes of the cervical vertebrae. Thus, there are two origins and one insertion. (Fig. 4-II)

In type III, the fasciculi corresponding to the three divisions are present but because of marked fusion they cannot be separated. Orang (Stewart) and Gorilla (Raven) belong to this category. As previously mentioned, however, there may be fusion between these three portions even in man and the reports by other investigators describing separation into three portions perhaps had been strained efforts to make such a division. According to my findings on the condition and nerve supply in Macaca cyclopis, it seems more appropriate in primates to separate this muscle into the superior and inferior portions at the level of the fifth cervical vertebra and include the medial portion in the inferior portion rather than attempt to separate the medial portion. In this type there are two origins and two insertions. (Fig. 4-III)

In type IV it is possible to separate the three portions, which had been incompletely separated in type II, such as in Tarsius, Chimpanzee, Hapale, etc., or in man.

Even in my cases of Macaca cyclopis, there was incomplete separation into the three portions. In other words, there is the part which arises from the upper thoracic vertebrae and inserts into the transverse processes of the sixth and seventh cervical vertebrae, the part which arises from the body of the lower cervical vertebrae and inserts into the body of the upper cervical vertebrae and the part which arises from the third to sixth cervical vertebrae and terminates at the first and second cervical vertebrae. Thus, it is not impossible to include them in this category. In this type, the form is that of three origins and three insertions.

In this type, in view of the condition of the nerve supply to the medial portion and the supralateral portion, the medial portion should be considered to be a division of the supralateral portion. In other
words, this type should be regarded as a further differentiated form of type III.

It should be mentioned that HOWELL & STRAUS in their publication on "The Anatomy of the Rhesus Monkey" make no mention of insertion into the transverse processes of the sixth and seventh cervical vertebrae so that there are two origins and one insertion. This differs from my findings for Macaca cyclopis, but because they have not presented a detailed description, any comment should perhaps be withheld, but I would only like to state that this seems to be strange.

3. **M. rectus capitis lateralis** (Fig. 1, 3)

This muscle arises by muscle from the anterior surface of the transverse process of the atlas above and along the origin of the M. atlanto-scapularis anterior. It runs upward in a slightly lateral-ward direction to insert by muscle into the lateral portion of the occipital bone.

Since the location of the origin of this muscle is such that it covers the foramen transversarium of the atlas, the anterior branch of the first cervical nerve emerges ventrally by piercing this muscle. This is a short but quite powerful muscle and its ventral surface is covered by considerably powerful fascia.

_Nerve supply:_ In all 50 sides, it was supplied by the anterior branch of the first cervical nerve which sends off a small branch at the point of penetration of this muscle or shortly after emerging from this muscle.

In primates, this muscle arises from the transverse process of the atlas and inserts into the basilar portion of the occipital bone. The findings in my cases of Macaca cyclopis do not differ from those in Macaca rhesus. In man, there are reports of cases with duplication of this muscle while others doubt any duplication (EISLER), but no excess muscle was found in Macaca cyclopis.

With respect to the nerve supply, this muscle is reported to be supplied by the anterior branch of the first cervical nerve in Gorilla (RAVEN) and by a short anterior branch from the nerve forming the plexus cervicalis in Macaca rhesus (HOWELL & STRAUS) so that there seems to be little difference from the condition in my cases of Macaca cyclopis. However, it is not certain whether the relation between the location of this muscle and the nerve is the same as in my cases.

4. **M. rectus capitis anterior** (Fig. 1, 3)

This is a small muscle which arises by muscle from the first cervical vertebra and runs medio-upward to the base of the skull.
Cases may be separated into those in which the origin extends over an area from the transverse process of the atlas, just medial to the origin of the M. rectus capitis lateralis, to the body of the atlas (34 sides, 68%) and those in which the origin is limited to the body of the vertebra (12 sides, 24%) or the transverse process (4 sides, 8%).

The insertion is by muscle into the basilar portion of the occipital bone in front of the foramen occipital magnum and behind the insertion of the M. longus capitis.

_Nerve supply:_ The supply to this muscle is by a branch from the anterior branch of the first cervical nerve which usually is given off together with the branch to the M. rectus capitis lateralis or after the branch to the M. rectus capitis lateralis is sent off (44 sides, 88%). In a small number of cases, it was supplied by a branch from the anastomosed branch from the first and second cervical branches (4 sides, 8%) or by a branch from only the second cervical branch (2 sides, 4%).

In Nycticebus and Tarsius, there is additional origin from the transverse process of the axis in addition to the atlas (MURIE, MIVART) while it is said that BURMEISTER has reported that muscle fibers are received from the second cervical vertebra and occasionally from the transverse process of the fourth cervical vertebra (MURIE). In Lemuroidea and most primates, it arises from the atlas from the area extending from the lower surface of the base of the transverse process to the anterior tubercle medially and inserts into the basilar portion of the occipital bone behind the M. longus capitis. The origin in Macaca rhesus is reported to be limited to the transverse process of the atlas (HOWELL & STRAUS), but contrarily such a form is rather infrequent in Macaca cyclopis in which the origin usually is more broad extending to the surface of the body of the vertebra. As an exception, it is reported to terminate at the periotii of the mastoid region in Nycticebus tardigradus (MIVART).

In man, this muscle may be absent (TESTUT, Le DOUBLE, etc.) or a separate, independent muscle (M. rectus capitis anterior medius) may be present on the medial side of this muscle (EISLER), but such a condition or tendency could not be found in Macaca cyclopis.

**SUMMARY**

1. **M. longus capitis**

This muscle arises by four heads from the transverse processes of the third to sixth cervical vertebrae. These unite to form a single belly which ascends to insert into the basilar portion of the occipital bone in front of the foramen occipital magnum.
It usually is supplied by short branches from the anterior rami of the second and third cervical nerves.

2. M. longus colli

Although there may be a tendency for this muscle to separate into three parts, i.e., the supralateral, infralateral and medial portions, there is particularly marked fusion between the medial and infralateral portion so that it seems more appropriate to divide it into the upper and lower portions from the level of the fifth cervical vertebra. In other words, the upper half arises from the transverse processes of the third to sixth cervical vertebrae and inserts into the anterior tubercle of the atlas and the anterior tubercles of the upper cervical vertebrae up to the fourth cervical vertebra. The lower half usually arises from the body of the sixth cervical vertebra to the fourth thoracic vertebra and inserts into the transverse process of the sixth or seventh cervical vertebra. However, there is fusion between these two portions without a definite separating boundary.

Moreover, usually, the upper half is supplied by short branches from the third to fifth cervical nerves while the lower half is innervated by the sixth to seventh cervical nerves.

3. M. rectus capitis lateralis

This muscle arises from the anterior surface of the transverse process of the atlas and inserts into the lateral part of the basilar portion of the occipital bone. It is supplied by the anterior ramus of the first cervical nerve.

4. M. rectus capitis anterior

This muscle arises from an area extending from the base of the transverse process to the body of the atlas and inserts into the basilar portion of the occipital bone. It is innervated by a branch from the anterior ramus of the first cervical nerve as is the M. rectus capitis lateralis.

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