A STUDY OF THE SCALENE MUSCLE MASS OF MAMMALIA

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Ronald Fadil Isaac, B. A.
The Ohio State University
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Approved by

George R. L. Gauthier
Adviser
Department of Anatomy
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INTRODUCTION

The scalenes are a group of deep neck muscles which occur in all mammals (7). Their cephalic attachments are on the transverse processes of a varying number of cervical vertebrae. Some genera exhibit slips which extend as far as the base of the skull. Caudally they attach to a varying number of ribs anywhere between the dorsal and ventral midline depending on the animal involved.

In the human they are muscles of inspiration acting to elevate the ribs. In addition, they may bend laterally, flex, or stabilize the cervical column. There is no reason to doubt that they fulfill similar functions in the other mammals.

The scalenes receive their blood supply from the cervical branch of the ascending cervical trunk. Their innervation is from the various nerves of the brachial and cervical plexus. According to Gegenbauer as cited by Morris (32), their embryonic origin is from portions of the cervical myotomes. In the adult form the most ventral portion of the entire mass is homologous to the intercostal muscles whereas the most dorsal portion is homologous to the levatores costarum.

This paper is the result of an undertaking to dissect and describe the scalenes of representative members of some of the mammalian orders.
A review of the literature revealed that the criterion for naming the different members of the scalene system apparently originated as a result of work done on the human in which three, sometimes four, scalenes occur. The most ventral member of the group is the anterior scalene (scalenus anticus). This muscle is separated dorsally from the other members of the group by the brachial plexus and subclavian artery. It is this particular relationship which is used as a criterion for identification of the scalenes among the members of the various mammalian orders by the majority of anatomists. However, in the course of this investigation it was discovered that the position of the brachial plexus and subclavian artery do not provide a clear-cut criterion for identification. In some cases the artery and plexus emerge on either side of a portion of the scalene mass. Moreover, many mammals exhibit a scalene mass which lacks a clean division into the usual three parts, presenting instead a series of slips fusing with each other in a complicated manner. In such cases the middle scalene of one worker may indeed correspond to the anterior or posterior scalene of another.

It was therefore decided to descriptively treat the scalenes as a muscle system exhibiting superficial and deep portions. Furthermore, since there exists a difference in opinion among workers as to whether the scalenes originate from the spinal column and insert on the ribs or vice-versa, it was decided to employ the term attachment, thus avoiding any implications concerning unidirectional function.
REVIEW OF THE LITERATURE

MONOTREMATA

There is only sparse literature concerning the scalene system of the monotremes. Christie-Linde (3) noted the lack of an anterior portion. Bronn (2) supported this finding and added that the monotreme scalene was an undivided mass which had its attachment on the first rib.

MARSUPIALIA

Bonn maintained that the marsupials lack a ventral scalene but have a dorsal group which is plainly divided into a medius and posticus. His conclusions were based on the relative position of the brachial plexus and subclavian artery. However, Forster's (10) findings on Didelphis virginiana (opossum) contradict Bonn's assertions. The latter worker divided the scalene mass into an A and A' portion.

That which he called portion A' took an almost perpendicular course from its cervical attachments on the anterior processes of C2 through C6 to its caudal attachment on the cranial border of the first rib. Portion A which had these same attachments split from the mass superiorly. This was the most ventral of the two muscle segments. Scalene A', however, was situated ventral to the subclavian...
vein and spinal nerves C7, C8, and T1. Nerves C4 and C6 emerged between portion A and the upper part of A' (the intertransversarii anterior longus).

The caudal attachments were as follows: A attached to the first, third, fifth, and according to Kohlbrugger as cited by Forster (10), infrequently to the second rib. A' attached to the first rib.

EDENTATA

Bronn (2) noted the absence of an anterior scalene in Dasypus (armadillo), Myrmecophaga (giant anteater), and Bradypus (three-toed sloth) based on the classical criterion. However, Mackintosh (22), working with Bradypus (Arctopithecus blainvillei), described an anterior and posterior scalene, probably corresponding to Bronn's medius and posticus. The anterior attached on the transverse processes of C3 through C6 and on the cranial border of the first rib. The posticus attached on the transverse processes of C6 and C7 and caudally on the last cervical rib.

Murie (25) in his observations on Arctopithecus blainvillei appears to confirm Mackintosh's findings when he states:

Whether owing to nuchal semi-anchylosis or related to the disposition of transverse processes and considerable calibre of the cervical plexus of nerves, etc., a scalenus anticus is deficient and what trifling of development there is appears to be homologous with the scalenus posticus or mayhap, in addition, the scalenus medius of man, an opinion also entertained by Hyrtl.
Among the insectivores a number of workers agreed that the hedgehogs *Gymnura, Erinaceus*, and the mole, *Talpinae* lack an anterior scalene lying ventral to the brachial plexus (2, 3, 5). The medius and posticus of *Gymnura* are united into a single mass with cervical attachments on the transverse processes of C2 through C6 and costal attachments on the first six ribs close to the origins of the serratus magnus. It is separated from the longus colli by the brachial plexus (2, 5). *Erinaceus* presents the same pattern except a small fasciculus, the posticus, is separated from the main mass to attach on the first rib only (2, 5).

Verma (35) observed that a condition similar to the latter exists in the Indian hedgehogs, *Hemiechinus auritus* and *Paraechinus mecropus*. These species lack a scalene mass ventral to the roots of the brachial plexus and subclavian artery. Verma divided the scalene mass dorsal to the plexus and artery into a dorsal, middle, and ventral portion. These, he maintains, are not clearly demarcated from each other but do have different costal attachments. The dorsal portion attaches to the dorsolateral portion of the third and fourth ribs and the transverse processes of C2 and C3. The middle portion attaches to the dorsolateral parts of the second through the fifth ribs. Anterior to the second rib this middle scalene portion is one mass with vertebral attachments on C3 through C6. The smallest division, the ventral portion, attaches to the first and second ribs.
only. The vertebral attachments are on the neural arches of C5 and C6. According to Verma, all divisions of the scalene system in *auritus* and *meccopus* are innervated by cervical nerves 6, 7, and 8.

*Centetes* (tenrec), *Microgale* (long-tailed tenrec), and *Solenodon* (alamiqui) possess the three classical scalenes with the anticus situated ventral to the brachial plexus (2, 5). In *Potamogale* (African water shrew) the scalenus anticus is present attaching to the transverse process of C4 as well as the first rib. The medius and posticus are represented by a single muscle. It has cervical attachments on the transverse processes of C4 through C7 and caudally it attaches to the first and fourth ribs. The axillary components cross over it. *Chrysochloris*, the golden mole, has only the scalenus anticus as shown by the brachial plexus which passes out between this muscle and the levator angulae scapulae. It extends between the cartilage of the first rib and the transverse processes of C3 through C6 (5). Dobson maintained that the absence of a medius and posticus is evidently due to the encroachment of the pectoralis major on that part of the thoracic wall into which these muscles are normally attached (5).

In the shrew, *Crocidura coerulea*, the scalene is a tough bundle attaching on the transverse processes of C4 through C6 and the fifth rib (3).

**CHIROPTERA**

According to Bronn, the European bat, *Vespertilio murinus*, lacks an anterior scalene. Its dorsal group is divided into a
scalenes medius and posticus. Macalister (19), however, observed three scalenes in the bat. The anterior was very small and in Vampyrops (white-striped bats) attached to the transverse process of the axis. The medius and posticus were united near their cervical attachments but separated at their costal attachments. The posticus did not extend below the fourth rib.

**RODENTIA**

In surveying the literature, it was found that differing conclusions have been drawn by many workers concerning the existence or nonexistence of scalenes in rodents which are homologous to those of man.

According to Howell (15), in most, if not all, rodents a strict homologue of man's ventral scalene seems to be absent since no part of the scalenus complex lies ventral to the brachial plexus and subclavian artery. He observed but one scalene in Dipodomys (jumping rat) which was dorsal to the brachial plexus and subclavian artery. This scalene was composed of five slips, caudally attaching to the second through fifth ribs. The slips on the fourth and fifth ribs were deep to the slips of the serratus magnus which, in turn, attached to the third and fourth ribs. Rostrally, all the slips were coalesced into one bundle which attached chiefly upon the atlas with only small fascicles to the transverse processes of C3, C4, and C5.

In jerboas, Howell described a ventral scalene which, however, was dorsal to the brachial plexus. It attached on the first rib,
the transverse processes of the cervical column and the ventrolateral process of the atlas. Dorsal to this "ventral scalene" there was a scalene mass which was more comparable to the scalene of *Dipodomys*. It attached caudally on the second, third, and fourth ribs but there was also a deep, small slip on the extreme dorsal part of the first rib. All these slips attached to the ventrolateral process of the atlas by way of a common tendon. Howell conjectured that the deep slip from the first rib may be the homologue of the posterior scalene of man.

Parsons (27) examined a total of 21 different *sciuromorphine* (squirrels) and *hysticomorphine* (porcupines) rodents. He employed the term *scalenus anticus* only when he observed a muscle mass attaching on the first rib between the subclavian artery and vein. When present, this muscle attached to the basioccipital of the skull by way of a tendon in front and internal to the levator claviculae. In *Coelogenys* (lowland paca) this muscle also possessed a few fibers from one or two cervical transverse processes. It was absent in the Old World porcupines *Hystrix* and *Sphingurus* and in all *sciuromorphines* but present in the following rodents examined by Parsons:

- *Aulacodus swinder nianus* (cane "rat")
- *Capromys pilorides* (jutia)
- *Myopotamus coypus* (coypu)
- *Octodon cumingii* (degu)
- *Lagostomus trichodactylyus* (vizcachon)
- *Chinchilla lanigera* (chinchilla)
- *Dasyprocta cristata* (acuchi)
- *Coelogenys paca* (lowland paca)
- *Cavia cobaya* (guinea pig)
- *Dipus hirtipes* (jerboa)
- *Alectaga indica* (five-toed jerboa)
- *Arctomys marmotta* (woodchuck)
Parsons described the scalenus medius and posticus together since in the animals he examined it was difficult to separate them from one another.

In *Aulacodus*, which exhibited the typical arrangement found in the family *Octodontidae*, the medius attached to the transverse processes of the first four cervical vertebrae. Its costal attachments were on the sides of the fourth and fifth ribs. The posticus, according to Parsons, attached to the transverse process of the last three cervical vertebrae and the first and second ribs. *Chinchilla* possessed an almost identical arrangement.

In *Hystrix* and *Sphingurus* only one muscle could be distinguished. It attached to the transverse processes of all the cervical vertebrae and caudally to the first four ribs.

In *Lagostomus* and *Coelogenys* the scalene attached to the transverse processes of all the cervical vertebrae. The slips from the anterior three or four vertebrae terminated on the outer surfaces of the second through fifth ribs interdigitating with the serratus magnus at their respective attachment points. In *Lagostomus* the scalene extended as far as the sixth rib. Moreover, fibers from the posterior cervical vertebrae had their costal attachments on the first rib behind the subclavian artery.

Among members of the guinea pig family, *Caviidae*, the fibers attaching to the sides of the third and fourth ribs, had cervical attachments on C3 and C4. The slip to the first rib came from all the cervical transverse processes.
Other work has been done on the sciuromorphine and hystri­
comorphine rodents. Dobson (6) examined Capromys melanus (jutia). Using the classical criterion, he recognized the presence of a medius and posticus only. He noted, as did Parsons, that the two muscles appeared to be united with costal attachments on the cartilages of the fourth through sixth ribs.

Observations on Dasyprocta and Cavia by Eisler (7) and Bronn (2) essentially agree with those made by Parsons. Bronn noted that the dorsal scalene group in Sciurus was plainly divided into a medius and posticus.

Two other works by Greene (11) and Rinker (31) merit consideration here. Greene described the scalene anatomy of the common laboratory rat Rattus norvegicus albinus. She sited Parson's anterior scalene criterion, i.e., a mass ventral to the subclavian artery and brachial plexus attaching on the first rib. On the basis of this, she stated that such a muscle does not, as a rule, exist in the rat. The medius is the most extensive with attachments on C2 through C7 and the first through sixth ribs. The posterior scalene has cervical attachments on the transverse processes of C2 through C7. Caudally, this mass forms two slips which interdigitate with the serratus magnus at their attachment points on the fourth and fifth ribs.

Rinker examined a number of different genera of rats. He described the scalene system as existing in two portions, but unlike Parsons and Greene, made no mention of their position relative to the brachial plexus and subclavian artery.
A discrete slip attaching on the first rib and on C2 through C7 constitutes the first portion. The second portion, dorsal and apparently superficial to the latter, has slip attachments on the third through fifth ribs. The slip to the fifth rib attaches deep to the slip of the serratus magnus from the fourth rib. The scalene slip of the fourth rib lies superficial to the afore-mentioned serratus slip but deep to the most anterior fibers of the external abdominal oblique. The scalene slips of ribs 3 through 5 are fused into a single mass anteriorly. The dorsal two-thirds of this mass is aponeurotic near the vertebral column and attaches by way of a tendon to the transverse process of the atlas. The rest of this scalene portion attaches by way of three thin tendons to the transverse processes of the second through fourth cervical vertebrae.

Of the four genera examined by Rinker, Sigmodon (cotton rat) and Neotoma (wood rat) bear the closest resemblance in scalene morphology. The other two, Peromyscus (deer mouse) and Oryzomys (rice rat) differ constantly in the following manner. Some of the fibers from the fourth rib are situated deep to the slip of the serratus magnus from the third rib. Oryzomys has, as a rule, no fibers attached to the fifth rib. Moreover, all the genera examined by Rinker possess a few fibers on the second rib except Peromyscus.

LAGOMORPHA

Among the Leporidae (hares and rabbits) the common laboratory rabbit has three distinct scalenes—the anterior, middle, and
posterior (1). The anterior or ventralis has cervical attachments on the transverse processes of C4 through C6, occasionally C7. Its costal attachment is on the anterior and lateral surfaces of the first rib. The middle attaches only to the transverse process of C5. Caudally, it attaches to the lateral surfaces of the third through fifth ribs (1, 33), with an inconstant slip to the second rib. The posterior or dorsalis has attachments to the transverse processes of C4 through C6. Caudally, it attaches to the most dorsal portion of the first rib.

The ventral scalene is more or less separated from the dorsal by the origin on the first rib of part of the cervical portion of the serratus magnus. The medius is the most superficial of the three portions.

Parsons (28) examined and described the scalenes of the African jumping hare *Pedetes caffer*. In this form no ventral scalene exists. The scalene system is divided into a longus and brevis. The longus has attachments on the transverse processes of C2 through C4 and caudally on the second rib only. The brevis is situated deep to the longus with cervical attachments to the transverse processes of C2 through C5. Its costal attachment is to the first rib only.

**ARTIODACTYLA**

Most of the myological observations on the Artiodactyla have been on domesticated animals, such as the horse, cattle, sheep, and pig.
The horse does not possess the classical ventral scalene (8). The scalene mass, called the scalenus primae costae by Sisson (34), is divided into two portions—the ventralis and dorsalis—both of which have their costal attachments on the anterior border and lateral surface of the first rib. The ventral portion attaches to the transverse processes of C4 through C6, whereas the smaller dorsal portion attaches to the transverse process of C7 only. These observations agree with those of Ellenberger and Baum (8) who noted the lack of a scalenus supracostalis (a scalene mass equivalent to the s. posticus which attaches to any of the ribs other than the first). Roots of the cervical portion of the brachial plexus emerge between the two portions.

The ass is similar to the horse in possessing only the scalenus primae costae (33).

In cattle, the scalenus primae costae is occasionally divided into the parts between which the subclavian artery passes. The part lying ventral to the artery is the anterior or ventral scalene (8, 34). The ventral scalene attaches to the transverse processes of C3 through C6 according to Ellenberger (8) or C3 through C7 according to Sisson (34). The dorsalis or supracostalis has attachments on the transverse processes of C4 through C6. Its wider posterior part lies on the ventral part of the serratus magnus and ends on the fourth rib. Ellenberger maintains that the emergence of the roots of the brachial plexus through the dorsal scalene mass occasionally splits off a small distinct scalene, the minimus, which
has a cervical attachment to the transverse process of C7. This may also occur in the horse and pig.

May (23) described a bipartite scalene in sheep—the scalenus ventralis and dorsalis. The roots of the brachial plexus pass through the ventralis which has attachments on the transverse processes of C3 through C7 and the first rib. The dorsalis has its attachments on the transverse processes of C4 through C6. Its costal attachments are on the third and fourth ribs. The dorsalis is laterally disposed to the origin of the cervical portion of the serratus magnus muscle. This description concurs with that of Sibson (33).

The pig exhibits a system, the scalenus ventralis, which resembles that of cattle by attaching to the last four cervical vertebrae. It is also split by the roots of the emerging brachial plexus. The dorsalis attaches to the transverse processes of C3 through C6 and extends as far as the third rib caudally (8, 34). On the basis of morphological description, this dorsalis appears to be the supracostalis muscle described by Ellenberger.

CETACEA

Howell (13), working with the Chinese Finless Porpoise (Neomeris phocaenoides), described two powerful scalenes—the ventralis and dorsalis. The latter attached primarily to the first rib with only a slight, more dorsal segment to the second rib. These two portions fuse to become a very thick single mass near the cervical column. Its attachment to the column is not by discrete slips but rather by
a continuous membrane which invests the transverse process of the fused axis, the caudal ridge and extremity of the transverse process of the atlas and the border of the exoccipital on the base of the skull.

The ventralis, according to Howell, had attachments on the costal cartilages of approximately the first five ribs. Its cephalic attachment was on the lateral border of the exoccipital.

Sibson (33) examined another species of porpoise and described an entirely different scalene system. He observed that the lung rose almost to the base of the skull. To the side and behind this lung apex was a large half cone-shaped scalene. This scalene half embraced the lung in the neck and attached on the whole circuit of the first rib and the costal half of the first costal cartilage. Anteriorly, the cone terminated in a tendinous attachment on the base of the skull. To the outside of this scalene segment Sibson described another shorter and smaller scalene with attachments on an anonymous transverse process and the first rib.

On the basis of position relative to the brachial plexus and subclavian artery, all whales seem to have only two divisions of the scalene mass, the anticus being the missing portion (13). In Kogia (pygmy sperm whale) the dorsalis and the much smaller ventralis (medius) attach to the first rib only with anterior attachments on the transverse processes of all the cervical vertebrae. The two divisions in Balaenoptera (whalebone whales) are part of an involved muscle complex. They both have costal attachments primarily on the first three ribs (13).
CARNIVORA

*Canis domesticus* (dog) has a scalene system situated entirely dorsal to the brachial plexus and subclavian artery; thus, it lacks an anterior scalene (2). The portion just dorsal to the plexus and artery is the scalenus ventralis (*s. primae costae*). Its costal attachments are on the first rib and its spinal attachment on the transverse processes of the last four cervical vertebrae (34). The scalenus dorsalis (*s. supracostalis*) is a large muscle which fuses with the ventralis anteriorly and splits posteriorly into two portions. The most dorsal portion attaches on the third and fourth ribs whereas the ventral portion attaches on the seventh, eighth, or ninth rib (8, 33, 34). Contrary to Sisson (34), Ellenberger (8) traced the fused scalene mass as far cephalad as the atlas.

*Felis domesticus* (cat) possesses a tripartite scalene system. According to most anatomists, all divisions lie dorsal to the subclavian artery and brachial plexus, although in some cases roots of the brachial plexus can be observed emerging through the portion of the anterior scalene which attaches to the first rib (30).

In addition to this mass to the first rib, the anterior scalene is also composed of slips which attach to the cartilages of the second and third ribs by way of two minute tendons. The medius is the largest member of the cat scalene system with slips attaching to the sixth through ninth ribs just dorsal to their cartilage junctions. At the level of the fifth rib all these slips are
continuous with one another existing as a fleshy bundle. The posterior scalene attaches by way of a tendon either to the third or fourth rib between heads of the serratus magnus, according to Reighard (30).

All the divisions (anterior, medius, and posterior) are united craniad of the level of the first rib. The united mass takes spinal attachments on the transverse processes of C1 through C7, occasionally T1 (30).

Macalister (20) observed the scalenes in his work with the Civet (*Viverra civetta*) and the Tayra (*Galera barbata*). The anticus in these animals was a small mass attaching to the transverse process of C6 and the first rib. The medius was observed to attach to the transverse processes of C3 through C6. Macalister did not include the costal attachments of this muscle. The posticus attached to the transverse processes of C4 through C6 and the third through sixth ribs.

Murie (24) did an anatomical treatise on the sea lion. Although he did not discuss the scalenes, they are clearly depicted in one of his figures. As he has them drawn, the scalene segments share a common attachment on the inferior or anterior surface of the transverse process of the atlas. It is shown to extend caudally, eventually splitting into two distinct bundles. He labeled the ventral bundle scalene 1 and the dorsal one scalene 2. Scalene 1 is shown to attach on the third rib, while scalene 2 is shown to attach on the first rib dorsolateral to scalene 1.

Howell (14) examined the eared (genus *Zalophus*) and earless (genus *Phoca*) seals. He considered the homologues of their scalenes
as being too uncertain to call them anticus, medius, and posticus. Therefore, he referred to them by number. In Zalophus, the slender scalene 1 attached to the third rib beneath a projection of the serratus magnus. Anteriorly, it weakly attached on C4. Scalene 2 was a finer muscle than the latter and was observed by Howell to attach to the first rib and the fourth and fifth cervical vertebrae.

Phoca presented a tripartite scalene mass. These three portions fused anteriorly to form a tapering cylindrical muscle which attached by way of a tendon on C3. That which Howell labeled as scalene 1 had costal attachments on the third through fifth ribs. Scalene 2 extended between the first rib and C4 through C6. Scalene 3 was just dorsal to the latter and also had its costal attachment on the first rib. Its attachments on the spinal column were on C3 through C6.

PRIMATES

Among the primates the scalenes present a diversified picture. Animals such as the Lemur, Galago, and occasionally the Orang-utan lack a scalene mass ventral to the axillary vessels and nerves. When present (in Macacus, Cercopithecus, and Anthropomorphic apes), the anterior portion has cervical attachments like those of the human (2).

The scalenes of the Macacus (rhesus monkeys) and Lemuroidea (lemurs) have received mentionable description by Hartman and Straus (12) and Murie and Mivart (26) respectively.

In the Macacus, Hartman and Straus recognize three scalene muscles—scalenus brevis anterior, scalenus longus, and scalenus
brevis posterior. The anterior is ventral to the brachial plexus and has a superior attachment on the transverse processes of C3 through C5 and a heavy portion to the ventral lamina of C6. Caudally, it attaches to the ventrolateral aspect of the cranial border of the first rib. The longus has a cervical attachment to the transverse process of C4, in some cases as high as the axis. Its caudal attachment is usually on the cranial borders of the third through fifth ribs. They report the fifth rib attachment to be inconstant and note that slips from the longus may also attach to the first and second ribs. The posterior scalene is dorsal to the brachial plexus with cephalic attachments on the transverse processes of the atlas through C7. Occasionally, the slip from the atlas may be absent. Its other attachment is to the dorsolateral aspect of the cranial border of the first rib.

Murie and Mivart examined a number of Lemuroidea and Galago (galagos). They report that the scalenes in Lemuroidea catta consist for the most part of two distinct portions dorsal to the brachial plexus and subclavian artery. The anterior mass is prolonged the furthest caudally with attachments on the second, third, and occasionally the fourth rib. These termination points are in intimate contact with part of the origin of the serratus magnus. Lemuroidea varius, Galago crassicaudatus, and Cheiromys (aye-aye) present similar pictures.

In Lemuroidea xanthomystax these workers report three or four scalenes, all of which are dorsal to the brachial plexus. The entire mass has four cervical attachments to the transverse processes
of C2, C4, C5, and C6. The two slips from C2 and C4 are fused distal to the processes but split into three fasciculi which attach on the second, third, and fourth ribs near the costal cartilage. The second and third rib attachment points are in close adherence and partial fusion with the serratus magnus. The tendons from C5 and C6 coalesce distal to the processes and attach as one mass on the cranial border of the first rib.

In Galago allenii, Murie and Mivart assert the presence of an anterior scalene which lies ventral to the last nerve of the brachial plexus and attaches on the first rib. This seems to be a fasciculus split from the rest of the scalene mass. The cervical attachments involve at least C4 and C6. In Tarsius (tarsier), they describe three "fascicles" with attachments on C1 through C6 and the first three ribs.

The human scalene system is divided into three, occasionally four, distinct parts. Regardless of the number of scalenes present in a given individual, they all have their costal attachments on the first rib except the posticus which may extend to the second.

The anterior scalene has its cephalic attachment on the anterior tubercles of the transverse processes of C3 to C6. It descends lateralward, anterior to the roots of the brachial plexus and attaches on the first rib anterior to the subclavian artery but posterior to the subclavian vein.

Just dorsal to the brachial plexus and subclavian artery is the scalene muscle referred to as the middle scalene (scalenus medius).
Superiorly, it attaches to the posterior tubercles of the transverse processes of C2 through C7.

The deepest scalene is the posterior scalene (scalenus posticus). Superiorly, it attaches to the posterior tubercles of the transverse processes of the lower two or three cervical vertebrae by way of separate tendons.

The fourth inconstant scalene muscle mass is called the scalenus pleuralis, or scalenus minimus. This very small muscle attaches to the transverse processes of C7 or C5, C6, and C7 (17, 32) and is said to terminate inferiorly as a fan-like aponeurosis over the cervical dome of the pleura and inner border of the first rib. This pleural termination has been called Sibson's fascia, or the supracleural membrane.

The latter is, indeed, the accepted general morphological description of the human scalenes, but the picture is not consistently clear-cut since the scalenes, like many other structures, are subject to considerable variations as brought to light by scattered investigations.

Hunt (16) dissected 29 South African Negro cadavers of the Bantu tribe. He discovered that a normal feature of these South Africans was a splitting of the anterior scalene by the roots of the brachial plexus and subclavian artery. A distinctive consolidated mass ventral to the plexus and artery was represented instead by a number of slips separated from each other by the emergence of the nerves of the plexus and the subclavian artery.
Knott (17) reported a series of other scalene variations. He noted cases in which the superior attachment of the middle scalene mass was on the anterior rather than posterior tubercles of the transverse processes and anywhere from three to seven vertebral attachments as opposed to a normal of six. In one case he found the middle portion extended as far as the second rib.

He found only two deviations associated with the deepest segment of the scalene mass (scalenus posticus). One case showed a complete absence, while in the other, the slip extended as far as the lower end of the third rib (17).

There is a greater incidence of variations in the previously mentioned scalenus minimus. Its incidence of occurrence has been reported at wide variance by different workers. According to Knott (17), Macalister found it in three of the seven cases he examined and Krause found it in 42 per cent of his cases. However, Knott reports it as well defined in only 5 out of 23 cadavers. Lazorthes (18) found it in all 18 of his dissections between the brachial plexus and subclavian artery, whereas E. Zuckerkandl as cited in Morris (32) found it a total of 45 times in 60 specimens; 22 times on both sides, 12 times on the right side, and 9 times on the left. When a definite minimus is missing, many workers have noted that it is replaced by ligamentous bands or fibrous tissue bearing the same inferior and superior attachments as the muscle slip (4, 32).

Knott reports two other variations of human scalene myology. One of these which he calls the scalenus lateralis (Albinus) is a
slip with a cervical attachment on the transverse process of C7 and an inferior attachment on the second rib. When present, it passes between the middle and posterior portions a little to the outside of the latter. The other case Knott refers to as the scalenus accessorius with a cephalic attachment to the posterior tubercles of the transverse processes of C4 through C6 or C4 through C7. Its attachment on the first rib was close to that of the middle scalene mass from which it is separated by part of the brachial plexus.
MATERIALS AND METHODS

The formalin-preserved specimens used in this study are listed below:

<table>
<thead>
<tr>
<th>Class</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marsupialia</td>
<td>Opossum</td>
</tr>
<tr>
<td>Edentata</td>
<td>Armadillo</td>
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<tr>
<td>Chiroptera</td>
<td>Bat</td>
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<tr>
<td>Rodentia</td>
<td>Woodchuck</td>
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<td></td>
<td>Guinea pig</td>
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<tr>
<td>Lagomorpha</td>
<td>Rabbit</td>
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<td>Artiodactyla</td>
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<td>Lamb</td>
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<tr>
<td>Carnivora</td>
<td>Cat</td>
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<td></td>
<td>Ferret</td>
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<tr>
<td>Primates</td>
<td>Rhesus monkey</td>
</tr>
<tr>
<td></td>
<td>Man</td>
</tr>
</tbody>
</table>

(Didelphis virginiana)  
(Dasypus novemcinctus)  
(Eptesicus fuscus)  
(Marmota monax)  
(Cavia porcellus)  
(Sylvilagus floridanus)  
(Sus scrofa)  
(Ovis aries)  
(Felis domesticus)  
(Mustela furo)  
(Macacus mullata)  
(Homo sapiens)

Gross dissection with the standard tools was the method of investigation employed. A five-inch circeline illuminated magnifying lens was occasionally used to assist the naked eye in the course of dissection.

New-born bats were used for the section on Chiroptera, and it was therefore necessary to conduct the entire dissection under a Bausch and Lomb binocular dissection scope. The photograph of this dissection is 14.5X actual size.
OBSERVATIONS

MARSUPIALIA

Opossum (*Didelphis virginiana*) Plates I and II

Upon examination of the scalene system of this species, it was found that the entire bipartite scalene system was situated dorso-lateral to the brachial plexus and subclavian artery. The most superficial portion had costal attachments on the third and fourth ribs beneath serrations of the serratus magnus muscle (Pl. I, fig. 1 and Pl. II, fig. 3). The deep scalene portion attached to the first rib only (Pl. I, figs. 1, 2).

The superficial slip had two cervical attachments on the transverse processes of C2 and C5 (Pl. II, figs. 3, 4). The deep mass had cervical attachments on the transverse processes of C2, C5, C7, and the lateral surface of the ventral lamina of C6. The attachment to C2 was by way of a tendon shared by the superficial portion (Pl. II, fig. 4). The superficial scalene mass appeared to be two fused portions with the bundles attached to the transverse process of C5, giving its fibers predominantly to the third rib and the bundle attached to the transverse process of C2, giving its fibers predominantly to the fourth rib (Pl. II, fig. 3).
Didelphis virginiana - Left scalene system, VENTRAL VIEW

Key to figures:

Fig. 1 - Superficial aspect of left scalene system.

sca. - Scalene muscle mass
sbc1. a. - Subclavian artery
br. plex. - Roots of the brachial plexus
CEPH. - Cephalic direction
R1,3,4 - Attachment points on ribs 1, 3, and 4.

Fig. 2 - Superficial scalene mass transected to demonstrate deep slip to the first rib.

SC2 - Distal end of tendinous slip to the transverse process of the second cervical vertebra.

SC5 - Distal end of tendinous slip to the transverse process of the fifth cervical vertebra.

SC6 - Muscle slip having attachment on the transverse process of the sixth cervical vertebra.
Didelphis virginiana - Left scalene system, VENTROLATERAL VIEW

Key to figures:

Fig. 3 - Superficial scalene mass transected and lapped back demonstrating various slips.

SC5 - Portion of tendon from transverse process of C5 to superficial mass.

serr. - Serrations of serratus magnus covering attachment points of superficial scalene on the third and fourth ribs.

Fig. 4 - Serratus removed demonstrating scalene slip attachment points on cervical column.

C2,5,6,7 - Attachment points on the transverse processes of cervical vertebrae 2, 5, 6, and 7. Note that C2 is the only tendinous attachment.
EDENTATA

Armadillo (*Dasypus novemcinctus*) Plate III

It was found in the dissection of *Dasypus novemcinctus* that the scalene system consisted of five bundles. Four of these were dorsolateral to the brachial plexus and subclavian artery and superficial to the fifth scalene muscle bundle.

The two superficial slips attaching to the first rib, as shown in Pl. III, fig. 5, had cervical attachments to the transverse process of the fused cervical vertebrae 4, 5, and 6. The other two superficial slips attaching to the second and third ribs (see Pl. III, fig. 5) had their cephalic attachment predominantly on the transverse process of C3 by way of a short tendon.

The deep scalene slip (Pl. III, fig. 6, "sca.") was a short, thick bundle attaching on the cranial border of the first rib close to the dorsal midline. Cervically, it attached to the transverse process of C7.

In the course of this dissection, a muscle labeled 'X' in fig. 6 was observed. This muscle attached to the dorsal surface of the first rib, took a curved course anterior to the cervical dome of the lung, descended dorsal to the lung, and took attachments on the first thoracic vertebra and the ventral aspect of ribs 2, 3, 4, 5, and 6 adjacent to the dorsal midline. No mention of this muscle could be found in the literature.
Key to figures:

Fig. 5 - Superficial aspect of right scalene system.

sca. - Scalene muscle mass
sbcl. a. - Subclavian artery
br. plex. - Brachial plexus
C3 - Pin inserted into transverse process of the third cervical vertebra.
R1,2,3 - Attachment points on ribs 1, 2, and 3.

Fig. 6 - Superficial scalene removed demonstrating dorsalmost scalene slip.

sca. - Scalene muscle mass situated deep to those in fig. 5.
R1 - First rib near costochondral junction.
mus. 'X' - See discussion on Page
sp. col. - Ventral surface of the spinal column
The scalene system of the new-born bat was found to be situated dorsal to the subclavian artery and the roots of the brachial plexus, except for one nerve which emerged dorsal to the scalene mass, then passed ventral to join the rest of the plexus.

The scalene was composed of fascicles which were discrete and spread out near their cervical attachments but fused caudally into a thin bundle just cranial to its attachment on the first rib. The fascicles attached on the transverse processes of C1 through C5 and the ventral lamina of C6.
PLATE IV

Eptesicus fuscus - Left scalene system, VENTRAL VIEW (14.5X)

Key to figure:

Fig. 7 - Ventral view of left scalene system, demonstrating relation to roots of brachial plexus and subclavian artery.

br. plex. - Note nerve joining plexus which emerges dorsal to scalene mass.

R1 - Lines indicate first rib; note attachment of scalene on the cranial border.
Woodchuck (*Marmota monax*) Plate V

*Marmota monax* possessed a tripartite scalene system situated completely dorsal to the subclavian artery and roots of the brachial plexus.

The system was found to be broad and flat caudally but narrow near the attachments on the cervical column. The fused slips had attachments predominantly on the transverse processes of C2, C5, and C6 with only slight attachments on the transverse processes of C4 and C7, possible C3.

The most ventral slip ("SC2" of fig. 8) was a small bundle situated just dorsal to the roots of the brachial plexus and subclavian artery. It attached on the first rib and predominantly to the transverse process of C2 (Pl. V, fig. 8) although some fibers blended with other portions of the scalene system to the other cervical vertebrae.

The other two fan-like scalene segments were fused just caudal to the level of the first rib. The most ventral of the two had costal attachments on the third, fourth, and fifth ribs. The attachment on the fifth rib was deep to a digitation of the serratus magnus. The other slip had an extensive attachment on the fourth rib which was also deep to a digitation of the serratus magnus.
PLATE V

*Marmota monax* - Left scalene system, LATERAL VIEW

Key to figure:

Fig. 8 - Lateral view of scalene system.

**C2,5,6** - Pins inserted into transverse processes of C2, C5, and C6 at points of scalene attachments.

**SC2** - Scalene slip attached to transverse process of C2 and the first rib.

**R1,3** - Pins inserted into first and third ribs at points of scalene attachment.

**R4,5** - Lines indicate extent of scalene slip attachment on the fourth and fifth rib.

**serr.** - Digitations of the serratus magnus which partially cover scalene attachment points on the fourth and fifth ribs.

Note: Arrow heads between first and third ribs indicate most ventral margin of scalene system.
Plate V
Dissection of *Cavia porcellus* disclosed a scalene system situated entirely dorsolateral to the brachial plexus and subclavian artery (Pl. VI, fig. 9). The superficial segment was a thin, flat sheet which fanned out before taking attachments on the first through fifth ribs. The attachment on the fifth rib was beneath a digitation of the serratus magnus. Anteriorly, the superficial mass attached to the transverse processes of C4 through C7.

The deep scalene slip was small and conical in shape. Its costal attachment was entirely on the first rib. Its spinal attachment was primarily on the transverse process of C7 (Pl. VI, fig. 10), although fascicles from the transverse processes of C4, C5, and possibly C6 contributed to its mass. These attachments were by way of tendons shared by the superficial segment.
Cavia porcellus - Left scalene system, LATERAL VIEW

Key to figures:

Fig. 9 - Scalene system superficial aspect.

scd. - Superficial scalene slip

Fig. 10 - Superficial scalene slip reflected to demonstrate deep scalene slip attaching on the first rib.

C7 - Deep slip attachment point on transverse process of C7.

R1 - Deep slip attachment point on the first rib.
LAGAMORPHA

Rabbit (*Sylvilagus floridanus*) Plate VII

The dissection of *Sylvilagus floridanus* revealed a scalene system situated entirely dorsal to the brachial plexus and subclavian artery. The superficial mass was narrow rostrally splitting caudally into three fan-like sheets which attached to the cranial and lateral surfaces of the second, third, and fourth ribs (Pl. VII, fig. 11).

The deep portion attached entirely on the first rib. Cervically this portion fused with the ventral surface of the superficial segment before the entire united mass attached on the transverse processes of C3 through C7 by way of tendinous slips (Pl. VII, fig. 12).
PLATE VII

*Sylvilagus floridanus* - Left scalene mass, VENTROLATERAL VIEW

Key to figures:

**Fig. 11** - Scalene system, superficial aspect.

- **R2,3,4** - Attachment points on ribs 2, 3, and 4 of superficial scalene mass.

- **visc.** - Visceral mass including esophagus and trachea.

**Fig. 12** - Superficial mass transected to demonstrate deep portion of scalene system.

- **R1** - Attachment of the deep scalene mass on the first rib.
ARTIODACTYLA

Pig (*Sus scrofa*) Plate VIII

The examination of new-born *Sus scrofa* revealed a tripartite scalene system. The superficial mass attaching to the first rib was dorsal to the subclavian artery but ventral to the brachial plexus (Pl. VIII, fig. 13). Another superficial mass was situated just dorsal to the brachial plexus. It attached to the second rib (Pl. VIII, fig. 13).

The mass to the first rib had spinal attachments on the transverse processes of C1 and C3 through C6, whereas the aforementioned portion to the second rib attached to the transverse process of C3 only.

Removal of the mass dorsal to the brachial plexus revealed the third scalene portion. This deep scalene portion was a small bundle composed of two slips which had attachments on the transverse processes of C4 and C5 (Pl. VIII, fig. 14). These attachments were shared by the attachment slips of the other scalene mass to the first rib.
Sus scorfa - Left scalene system, VENTROLATERAL VIEW

Key to figures:

Fig. 13 - Superficial aspect.

R1 - Attachment point of the most ventral scalene mass on the first rib.

R2 - Attachment point of the most dorsal superficial scalene mass on the second rib.

Fig. 14 - Most dorsal superficial scalene mass removed to demonstrate deep scalene slip.

SC5 - Slip attaching to the transverse process of C5 which contributes to the deep scalene mass. Roots of the brachial plexus emerge on either side.

R1 (probe) - Probe point indicates attachment point of deep scalene mass on the first rib.

R1 (pin) - Pin is inserted into first rib near attachment point of the most ventral scalene mass.
Sheep (*Ovis aries*) Plate IX

The scalene system of the sheep was found to be composed of six discrete slips, all of which had their costal attachments on the cranial border of the first rib.

The most superficial slip was dorsolateral to roots of the brachial plexus and ran parallel to the spinal column. It attached on the transverse process of C5 by way of a tendon common to another scalene slip. Its costal attachment was in close proximity to the neck of the first rib (Pl. IX, fig. 15).

The other five slips had a tangential displacement to the spinal column. Roots of the brachial plexus emerged between some of these slips near their attachments on the transverse processes of C5, C6, and C7 respectively (Pl. IX, fig. 16). There were also slip attachments on the transverse processes of C3 and C4. These five slips were fused caudally and attached as a single bundle on the first rib near the sterno-costal junction, dorsal to the subclavian artery (Pl. IX, figs. 15 and 16).
PLATE IX

Ovis aries - Right scalene system, VENTROLATERAL VIEW

Key to figures:

Fig. 15 - Intact scalene system.

C5 - Pin inserted into transverse process of C5. Note attachment of dorsolateral scalene slip at this point.

R1 - Lines indicate first rib. Scalene slips are attached on the cranial border.

Fig. 16 - Dorsolateral scalene slip removed to demonstrate cervical attachment points.

C3, 4, 5, 6, 7 - Pins are inserted into the transverse processes of the third through seventh cervical vertebrae at the points of scalene tendon attachments.
CARNIVORA

Cat (Felis domesticus) Plate X

An extensive, well-developed scalene system was found in the cat. It was composed of four discrete portions, all of which were situated dorsolateral to the roots of the brachial plexus and subclavian artery (Pl. X, fig. 17).

The most ventral bundle attached predominantly on the ventral surface of the first rib; however, a small fasciculus of its fibers was continuous with the transversus costarum (Pl. X, figs. 17, 18). Just dorsal to the latter bundle was another scalene slip which split into two portions. One of these attached on the fourth rib beneath a digitation of the serratus magnus. The other portion terminated on the ventral surface of the serratus magnus in a fan-like aponeurosis which extended from the fifth to eighth ribs (Pl. X, fig. 17 and inset). The most dorsal scalene bundle attached to the third rib, descended beneath a digitation of the serratus magnus, and took another attachment on the fourth rib (Pl. X, fig. 17).

Attachments on the spinal column were on the transverse processes of C3 through C6. The most dorsal portion attached exclusively to the transverse process of C3 by way of a long tendon (Pl. X, fig. 18). All the other segments shared common attachments on the transverse processes of C3 through C6.

A root of the brachial plexus was seen to emerge dorsal to a segment of the most ventral scalene which attached on the transverse process of C6 (Pl. X, fig. 18).
PLATE X

Felis domesticus - Left scalene system, VENTROLATERAL VIEW

Key to figures:

Fig. 17 - Superficial aspect of left scalene system.

tr. cos. - transversus costarum muscle

R3, 4 - Indicate attachment points of scalene slips on the third and fourth ribs beneath serratus magnus digitations.

ins. - Inset showing aponeurotic termination of longest scalene slip between the fifth and eighth ribs.

Fig. 18 - Demonstration of cervical attachment points.

tend. - Tendon attaching to transverse process of C3, continuous with most dorsal scalene bundle.

C3, 4, 5, 6 - Pins inserted into transverse processes of C3 through C6 at scalene attachment points.

fasc. - Fasciculus from most ventral scalene bundle which was continuous with transversus costarum.
Plate X
Ferret (Mustela furo) Plate XI

This carnivore possessed a scalene system completely dorsal to the subclavian artery and roots of the brachial plexus. The slips which comprised the system were slender and long, extending along the lateral wall of the rib cage.

Superficial examination revealed three scalene slips. The slip just dorsal and lateral to the subclavian artery and roots of the brachial plexus attached on the first rib. A small fasciculus of fibers from this slip was found to be continuous with the body of the transverse costarum (Pl. XI, fig. 20).

The next superficial slip dorsal to the latter extended the furthest caudally. A small fasciculus split from this slip at the level of the third rib and took an attachment on the lateral surface of the fourth rib superficial to a digitation of the serratus magnus (Pl. XI, fig. 19). The remainder of the slip became aponeurotic caudal to the fourth rib and terminated on the lateral surface of the fifth rib deep to a digitation of the serratus magnus.

The most dorsal superficial slip attached to the third rib deep to a digitation of the serratus magnus (Pl. XI, fig. 19).

Transection and reflection of the superficial slips revealed two additional scalene slips which attached on the dorsolateral portion of the first rib near the neck of the rib.

54
All the superficial and deep slips fused with each other near the cervical column. The fused mass attached directly to the transverse processes of C1 through C6. No discrete tendons were apparent. Incidental to these attachments was a small group of fibers continuous with the scalene mass but extending between the transverse processes of the atlas and axis.
PLATE XI

Mustela furo - Left scalene system, LATERAL VIEW

Key to figures:

Fig. 19 - Superficial aspect of left scalene system.

serr. - Digitations of the serratus magnus
R1,4 - Tip of line indicates scalene slip attachment points on the first and fourth ribs.

Fig. 20 - Superficial slips reflected to demonstrate deep slips to the first rib.

tr. cos. - Transverse costarum muscle
fasc. - Fasciculus from scalene slip continuous with the transverse costarum.

56
Macacus mullata presented a highly complex scalene system composed of many interrelated bundles. However, for purposes of discussion, the entire system can be divided into three areas. Two of these were superficial to the third. The superficial bundle attaching to the first rib was, for the most part, ventral to the roots of the brachial plexus (Pl. XII, fig. 21). A slip which contributed to this mass and was attached to the transverse process of C5 was found to lay dorsal to a root of the brachial plexus (Pl. XII, fig. 22).

However, in two other Mullata specimens which were examined, the scalene system was completely dorsal to the subclavian artery.

The other superficial mass was situated entirely dorsal and lateral to the roots of the brachial plexus and subclavian artery (Pl. XII, figs. 21 and 22). This bundle was split into discrete slips which had costal attachments on the first, third, fourth, and fifth ribs (Pl. XIII, fig. 24).

The deep bundle was composed of three distinct slips, all of which attached on the cranial border of the first rib deep to the superficial mass to the first rib and the axillary components (Pl. XIII, fig. 23).
The cervical attachments of the scalene system were complex. There were scalene tendon attachments on the transverse processes of C2 through C6 (C7?). Tabulated, they were as follows:

<table>
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<tr>
<th>Tendons on the Transverse Process of</th>
<th>Contributed Muscle Slips Which Attached on Ribs</th>
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</thead>
<tbody>
<tr>
<td>C2</td>
<td>1,3</td>
</tr>
<tr>
<td>C3</td>
<td>1,3,4</td>
</tr>
<tr>
<td>C4</td>
<td>1,3,4,5</td>
</tr>
<tr>
<td>C5</td>
<td>1</td>
</tr>
<tr>
<td>C6</td>
<td>1</td>
</tr>
<tr>
<td>C7</td>
<td>1</td>
</tr>
</tbody>
</table>

It was not possible to determine the total number of slip attachments since the entire complex exhibited extensive fusion.
Macacus mullata - Left scalene system, VENTRAL VIEW

Key to figures:

Fig. 21 - Superficial aspect of scalene system demonstrating scalene bundles lying ventral and dorsal to the brachial plexus.

Rl - Attachment point of most ventral scalene bundle on the first rib.

Fig. 22 - Superficial aspect of scalene system demonstrating attachment points as well as the subclavian artery and brachial plexus roots.

sbcl. a. - Subclavian artery emerging through the body of the most ventral scalene bundle.

C2,3,4,5,6 - Attachment points of the various scalene tendons on the transverse processes of the second through sixth cervical vertebrae.

SC5 - Slip or fasciculus of the most ventral scalene bundle attaching to the transverse process of C5. It is split from the main bundle by a portion of the brachial plexus indicated by the tip of the probe.
Macacus mullata - Left scalene system, VENTRAL VIEW

Key to figures:

Fig. 23 - Most ventral mass removed demonstrating deep bundles attaching to the first rib and cervical column.

*C2,3,4,5,6* - Attachment points of various scalene slips on the transverse processes of the second through sixth cervical vertebrae.

*R1* - Indicates attachment point of deep scalene bundles on the first rib.

Fig. 24 - Demonstration of scalene bundles to lower ribs.

*C2,3,4* - Pins inserted in the transverse processes of the second through fourth cervical vertebrae.

*SC2* - Slip split from the bundle with tendinous attachment on transverse processes of C2.

*R1* - Pin inserted into first rib at the attachment point of SC2.

*R3,4,5* - Attachment points of most dorsal scalene bundles on the third through fifth ribs.
The human scalene system was composed of three portions. Inspection of the ventral surface revealed that one of the portions was situated anterior to the subclavian artery and roots of the brachial plexus. This portion was composed of a number of discrete slips all of which had their costal attachment on the cranial border of the first rib (Pl. XIV, fig. 25). This portion is the anterior scalene of other workers.

The second portion, situated just posterior to the subclavian artery and brachial plexus was composed of two slips which attached to the transverse processes of C6 and C7 respectively (Pl. XIV, fig. 25). These slips were fused just cranial to their attachment on the cranial border of the first rib. A cervical nerve was found to emerge through this fused section, thus effecting a resplitting of the fused slips. This scalene portion is the scalenus minimus described in the literature.

Inspection of the lateral aspect of the specimen revealed the third scalene portion situated posterior and lateral to the subclavian artery and roots of the brachial plexus (Pl. XIV, fig. 26). This portion was also composed of a number of fused slips which attached primarily on the first rib (Pl. XIV, fig. 26). A few
fibers of the most posterior portion, however, extended to the second rib as an integral part of the intercostal band.

The entire portion posterior to the brachial plexus and subclavian artery is the fused middle and posterior scalene as referred to in the literature.

The slips contributing to the anterior portion had superior attachments on the transverse processes of C4 through C6. The slips constituting the posterior portion had superior attachments on the transverse processes of C2 through C6.
PLATE XIV

Homo sapiens - Left scalene system, VENTRAL AND LATERAL VIEWS

Key to figures:

Fig. 25 - Ventral aspect of left scalene system.

R1 - Attachment point of most anterior scalene portion on the cranial border of the first rib.

C6,7 - Pins are inserted into the transverse processes of C6 and C7 and inferiorly on the first rib dorsal to the subclavian artery.

phren. - Phrenic nerve.

Fig. 26 - Lateral aspect of scalene system.

R1 - Attachment point of most posterior scalene portion on the first rib.
DISCUSSION

After consideration of the literature and observations pertaining to this study, certain points merit consideration. They are as follows: (1) The constant and varying morphological features of the mammalian scalene system; (2) the value of the subclavian artery and brachial plexus criterion in scalene nomenclature; and (3) the ontogenetic implications of mammalian scalene morphology.

1) The Constant and Varying Morphological Features of the Mammalian Scalene System.

The scalene system has been observed to be one which exhibits a great deal of morphological variation throughout the mammalian orders. Its cephalad attachments are, as a rule, confined to the transverse processes of the cervical vertebrae, but rare cases may include the base of the skull as in some of the Cetacea. Caudally, the system attaches on the rib cage (in some instances as far as the eighth rib) anywhere between the ventral and dorsal midline. This particular topographical variation has functional significance. In those animals whose scalene system has costal attachments relatively close to the ventral midline, a greater elevation of the rib cage can be realized during scalene contraction and, conversely, a more effective flexion of the neck when the rib cage is fixed. In
addition to the latter features, the scalene system may exhibit aponeurotic, tendinous, and direct attachments to the column and ribs.

Sibson (33) generalized that the scalenes are well developed in those animals whose necks are incapable of extensive mobility but rather undeveloped in those animals with mobile necks. However, there doesn't appear to be enough consistency in this generalization since animals such as the ferret (Plate XI) and cat (Plate X) have extensive scalene systems as well as neck mobility. Conversely, the armadillo (Plate III) has an inflexible neck coupled with a comparatively small scalene system.

In addition to the inability to justifiably assert broad generalizations such as the latter, it is difficult to find scalene consistency within species themselves. For example, in Felis domesticus Reighard (30) noted an attachment on the second rib whereas the scalene system of Felis domesticus as observed in this undertaking lacked this attachment (Plate X). Other examples of variations within species include Macacus mullata (Plate XII, XIII) and Homo sapiens (p. 21 and Plate XIV).

Despite the apparent lack of uniformity in scalene morphology, a few characteristics are noteworthy. With certain exceptions, such as some of the primates, mammals possess scalene systems which, for the most part, are dorsal to the subclavian artery and the roots of the brachial plexus.

Another interesting point arising from this study and the observations of Ellenberger (8) is the scalene uniformity among the domestic
Artiodactyls. The horse, cattle, sheep, and pig all have scalene systems in which the brachial plexus and subclavian artery emerge separately on either side of a portion of the scalene system. The plexus is consistently dorsal and the artery ventral to a scalene slip (see Plates VIII and IX).

The fact that certain carnivores of the suborder Fissipedia possess extensive scalenes may indicate a group characteristic. In the domestic cat and dog the scalene system extends as far as the eighth rib (8,30 see also Plate X). In the civet and tayra the scalene slips extend as far as the sixth rib (20). The ferret is still another carnivore with an extensive scalene system extending as far as the fifth rib (see Plate XI).

2) The Value of the Subclavian Artery and Brachial Plexus Criterion in Scalene Nomenclature.

The classical criterion of topographical position relative to the subclavian artery and brachial plexus as a method of nomenclature has created a great deal of confusion rather than uniformity in the literature. Different investigators working with the same species have employed different names for the same scalene portion. A typical example of this confusion is in the work done on Arctopithecus blainvillei by Bronn (2) and Mackintosh (22).

Bronn described this edentate as having a scalenus medius and posticus both of which were situated dorsal to the brachial plexus and subclavian artery, thus following the classical criterion. Mackintosh, however, named these same muscles the anterior and posterior
scalenes. The name "anterior scalene" implies that this portion is situated ventral to the plexus and artery when, indeed, it is not.

In reviewing the literature, it was obvious that the most lucid descriptions of scalene morphology were obtainable when names were ignored in preference to specific description of attachments and topographical location. To merely state that a given mammal possesses or lacks an anterior, middle, or posterior scalene only results in ambiguity. Moreover, since the system is usually one of great complexity, it is far more profitable to the science of morphology if investigators give detailed descriptions of the system's slips, attachments, and topographical location.

Cases such as the bat (Plate IV), pig (Plate VIII), sheep (Plate IX), and monkey (Plates XII, XIII) involve systems which are virtually impossible to separate into an anterior, middle, or posterior scalene on the basis of the classical criterion.

Still another negative aspect of the nomenclature criterion is the erroneous implications of homology. Howell (15) claimed that a strict homologue of man's ventral scalene was absent in most rodents since no part of the scalene complex was situated ventral to the brachial plexus and subclavian artery. However, the scalene system in rodents, whether ventral or dorsal to the artery and plexus, is intrinsically similar to that of man in the following respects. It has similar anatomical construction, function, and topographical position. Moreover, embryonic origin and development are probably similar. Thus, on this basis, the scalene systems of both rodents and man are strictly homologous.
3) The Ontogenetic Implications of Scalene Morphology.

The fusion which the scalene system occasionally exhibits with such muscles as the longus colli, intervertebral masses, transverse costarum (see Plates IX and X), and portions of the serratus magnus suggests that these muscles took part of their embryonic origin from the same cervical myotome. If this is the case, incomplete degeneration of portions of the myotome to form tendons and/or aponeurosis would account for the partial fusion of these muscles with the scalene system.

The particular morphology of many scalene systems also suggest that the number of slips present may be determined by the emergence route taken by nerves of the brachial plexus through the primordial scalene mass. The monkey (Plates XII and XIII), sheep (Plate IX), and cat (Plate X) are good examples of this possibility. The course of emergence taken by the subclavian artery may also be of developmental significance in the case of the inconstant "scalenus minimus" found in humans (Plate XIV, fig. 25). In some specimens it has been found inseparably adherent to the anterior scalene mass suggesting it may be a slip of muscle which split off the larger anterior mass by the emerging subclavian artery during the course of embryonic development. There is some evidence which supports this hypothesis (9, 17).

It is further possible that the preponderance of scalene systems above the brachial plexus and subclavian artery among the mammals is of embryonic significance. In these cases it is feasible that the
cervical myotome portions destined to form the scalene system migrate ventrally at a slower rate relative to the rate of plexus and artery formation. Thus, when the primordial muscle mass comes into its position lateral to the spinal column the artery and nerves have extended to such a point that it is no longer possible for them to grow through the myotome but are now situated entirely ventral to the scalene mass. Conversely, those animals in which the artery and nerves are found to emerge through the scalene system may have had a development in which the primordial scalene mass descended earlier than the time for brachial plexus and subclavian artery development. If this is the case, the emerging nerves and artery would course through the scalene enroute to the forelimbs.
SUMMARY

The scalene systems of twelve different mammals were grossly dissected and described without employing the standard nomenclature criterion which involves the relative position of the roots of the brachial plexus and subclavian artery. The costal and cervical attachments and topography were found not only to be of great variance throughout the mammalian orders but within the species themselves.

The great complexity which the system may exhibit coupled with the particular arrangement of the roots of the brachial plexus and subclavian artery appears to have ontogenetic significance.
CONCLUSIONS

1) The mammalian scalene system is one of greater variance and complexity than heretofore realized.

2) The brachial plexus and subclavian artery nomenclature criterion is inapplicable and causes confusion in scalene anatomy.

3) The scalene system of a given mammalian group can only be characterized in very general terms.

4) The particular arrangement of the nerves of the brachial plexus and the subclavian artery has a number of implications concerning scalene ontogeny.
LITERATURE CITED


2) Bronn, H. G. 1874-1900 Klassen und Ordnungen Des Thier Reichs (Saugethiere) Bd.6 Abt.5 Buch 1, Leipzig, pp. 716-717.


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