Gross anatomy of the deep perivertebral musculature in horses

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Objective—To determine the gross morphology of the multifidus, longus colli, and longus thoracis muscles in the cervical and cranial thoracic portions of the equine vertebral column.

Sample—15 horse cadavers.

Procedures—The vertebral column was removed intact from the first cervical vertebra (C1) to the seventh thoracic vertebra (T7). After removing the superficial musculature, detailed anatomic dissections of the multifidus, longus colli, and longus thoracis muscles were performed.

Results—The multifidus cervicis muscle consisted of 5 bundles/level arranged in lateral, medial, and deep layers from C2 caudally into the thoracic portion of the vertebral column. Fibers in each bundle attached cranially to a spinous process then diverged laterally, attaching caudally on the dorsolateral edge of the vertebral lamina and blending into the joint capsule of an articular process articulation after crossing 1 to 4 intervertebral joints. The longus colli muscle had ventral, medial, and deep layers with 5 bundles/level from C1 to C5 that attached cranially to the ventral surface of the vertebral body, diverged laterally and crossed 1 to 4 intervertebral joints, then attached onto a vertebral transverse process as far caudally as C6. The longus thoracis muscle consisted of a single, well-defined muscle belly from C6 to T5-T6, with intermediate muscular attachments onto the ventral aspects of the vertebral bodies, the intervertebral symphyses, and the craniomedial aspects of the costovertebral joint capsules.

Conclusions and Clinical Relevance—Results indicated that there were multiple, short bundles of the multifidus cervicis, multifidus thoracis, and longus colli muscles; this was consistent with a function of providing sagittal plane intersegmental vertebral column stability. (*Am J Vet Res* 2014;75:433–440)

The neck comprises approximately 6% of the total body mass of horses,[1] with most of this mass consisting of muscular tissue. The neck connects the head with the trunk, allowing freedom of movement and stability of orientation for visual and vestibular inputs. This is facilitated by 3-D motion of the cervical intervertebral articulations[2–6] controlled by superficial and deep musculature and the nuchal ligament.[7–9] The gross anatomy of the cervical musculature of horses has been described in anatomic textbooks.[10–13] In addition, the length, attachments, innervation, and fiber types of the superficial intrinsic muscles, semispinalis capitis and splenius muscles, have been described in detail.[7] In addition, the role of those muscles in locomotor biomechanics[8,9,14,15] and their importance in providing stability for visual and vestibular function (which influence sensing of head and neck position)[5] have been described. The superficial extrinsic brachiocephalicus muscle has been classified as a forelimb locomotor muscle rather than a cervical positioning muscle on the basis of its phasic contraction pattern during locomotion.[14]

Abbreviations

APA	Articulation of vertebral articular processes
CSA	Cross-sectional area

Only a small amount of information is known about the structure and function of the deep perivertebral muscles in horses; such muscles are thought to have a role in postural stability of the cervical portion of the vertebral column during static and dynamic conditions. Anatomic descriptions of the arrangements of muscular bundles and attachments of the multifidus cervicis and longus colli muscles in horses vary and are typically vague. For example, the multifidus cervicis muscle has been described to have 5 or 6 segments with the superficial fibers oriented in an oblique craniomedial to caudolateral direction from APAs to the spinous processes of preceding vertebrae[11] and as representing the "deepest layer of the long muscles of the neck and back which extend from the sacrum to the second or

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third cervical vertebrae."[12] Getty[11] described the longus colli muscle as having thoracic and cranial parts with origins on the 5th or 6th thoracic vertebra but did not describe details regarding the attachments or the precise number of muscle bundles. Dyce et al[13] described the multifidus cervicis muscle as a "less important and obviously more segmental muscle" that forms part of the transversospinalis system; however, those authors did not mention the longus colli muscle.

For quadrupeds, information regarding the multifidus cervicis and longus colli muscles has only been described for rhesus monkeys[16] and dogs,[17] to the authors' knowledge. The importance of those muscles for sensing of head and neck position has been determined for rhesus monkeys on the basis of morphometric muscle characteristics and attachments,[16] and their contribution to dynamic motion of the cervical portion of the vertebral column in dogs has been determined on the basis of morphometric measurements.[17] Much less information has been published regarding the deep musculature of the cervical portion of the vertebral column in horses. In prominent anatomic texts, multifidus cervicis and longus colli muscles have only a brief description[11] or a cursory mention in the description of their anatomic region.[10,13]

In contrast to the small amount of information regarding such muscles in domestic animals, an extensive amount of information regarding deep musculature of the cervical portion of the vertebral column has been determined for humans. To the authors' knowledge, there are > 55 publications regarding the morphology, function, association with neck pain, stability, and neuromotor control of the perivertebral muscles in humans. The multifidus cervicis and longus colli muscles are considered to be functional stabilizers of the cervical portion of the vertebral column,[18] with the multifidus cervicis muscle providing spinal extension[19] and segmental stability[20] in a tonic manner and the longus colli muscle providing cervical flexion[21] and postural stability[18] in a phasic manner. Fibers of the multifidus cervicis muscle attach to part of the joint capsules of the APAs, potentially affecting degenerative joint disease processes associated with neck pain.[22] Knowledge of the anatomy of the deep perivertebral musculature of the cervical portion of the vertebral column in horses is essential for understanding the role of the multifidus cervicis and longus colli muscles in spinal stability and sagittal motion and the potential involvement of those muscles in neck dysfunction or pain. The objective of the study reported here was to determine the gross morphology of the multifidus cervicis and longus colli muscles in horses. This information was intended to improve understanding of the role of those muscles in stability and motion of the necks of horses.

Materials and Methods

Samples—This study was approved by the Michigan State University Institutional Animal Care and Use Committee. The architecture and morphology of the multifidus cervicis and longus colli muscles were determined by means of detailed gross dissection in the cervical and cranial aspect of the thoracic portion of the vertebral column of 15 horses that were euthanized for reasons other than signs of primary neck pain. The horses included 9 mares and 6 geldings (age range, 5 to 29 years; mean ± SD age, 18.3 ± 7.3 years) of various breeds (6 Thoroughbreds, 3 Quarter Horses, 2 Warmbloods, 1 Arabian, 1 draft horse, 1 pony, and 1 unknown). Horses were euthanized by IV administration of pentobarbital sodium (86 mg/kg), and viscera were removed carefully to avoid damaging the thoracic portion of the longus colli muscle, which is adjacent to the ventral surface of the vertebrae and has attachments as far caudally as T5 or T6.[11,12] After disarticulation of the head at the atlantooccipital joint, the forelimbs and extrinsic musculature were removed. The first 8 (true) ribs were transected 15 cm ventral to the costovertebral joints, and the sternum was removed. The costovertebral and costotransverse joints were then disarticulated from the vertebral bodies. The thoracic portion of the vertebral column was disarticulated between T7 and T8, which is caudal to the most caudal vertebral attachment of the longus thoracis muscle.

Anatomic dissection—Each prepared anatomic specimen including the vertebral column from C1 to T7 was placed on a lateral side on a dissection table. Superficial layers of the cervical and scapulothoracic portions of the musculature were carefully removed after identification of intermuscular septa and separation along the fascial divisions, until the deep perivertebral portion of the musculature was exposed. The lamellar and funicular portions of the nuchal ligament were left intact. The superficial muscles that had direct attachments onto the dorsal and ventral aspects of the body, transverse processes, and articular processes of the vertebrae were removed carefully, to avoid damaging attachments of the deep muscles to these structures.

The multifidus muscle was exposed from C2 to T7 by peeling off the fascial attachments of the trapezius cervicis and trapezius thoracis muscles from the funicular portion of the nuchal ligament (cervical region) and the supraspinous ligament (thoracic region). The rhomboideus muscle was removed by dissecting along its borders with the splenius muscle, the funicular portion of the nuchal ligament, and the spinalis thoracis muscle. The brachiocephalicus and omotransversarius muscles were reflected; the omotransversarius muscle was reflected from its fascial attachments to the dorsal aspects of the transverse processes of C2, C3, and C4. The serratus cervicis muscle was retracted along its fascial separation from the splenius muscle (medially) and from its fascial attachments to the dorsal aspects of the transverse processes of C3 through C7. The longissimus capitis and longissimus atlantis muscles were removed by careful dissection from their fascial connections with the joint capsules of the APAs from C2-C3 through C7-T1. The fascial attachments of the semispinalis capitis muscle were removed from the joint capsules of the APAs from C3-C4 to C6-C7. The iliocostalis cervicis muscle was removed from its most cranial attachments to the transverse processes of C6, C7, and T1. The longissimus cervicis muscle was removed from its attachments to the transverse processes of C4 to C7. The spinalis cervicis muscle was identified lateral to the fibrous remnants of the lamellar portions of the nuchal ligament at the level of C4-C5, C5-C6, and C6-C7 and medial to the multifidus cervicis muscle, with a strong tendinous interdigitation with fibers from the multifidus muscle at the level of C7. Caudal to C7, the spinalis cervicis muscle was located lateral to the multifidus thoracis muscle in the cranial aspect of the thoracic portion of the vertebral column, where it bridged the concavity in the curvature of the dorsal aspect of the vertebral column in the caudal aspect of the cervical region and attached firmly onto the dorsal spinous processes from T1 to T3. Following isolation of the intact muscle, the multifidus cervicis muscle was divided into 3 layers[23,24] in accordance with the relative positions from superficial to deep and lateral to medial, the vertebral attachments, and the number of vertebrae crossed. The 3 layers were divided into bundles by careful separation of muscle fiber bundles along the fascial planes and in accordance with the attachment sites. The segmentally arranged bundles were described from their cranial to their caudal attachments.[25]

The cervical and cervicothoracic portions of the longus colli muscle were isolated by careful removal of the superficial musculature, the esophagus, and the trachea. The remnants of the sternocephalicus, sternothyroideus, and omohyoideus muscles were removed, exposing the longus capitis muscle in the cranial aspect of the cervical portion of the vertebral column and the scalenus medius muscle in the caudal aspect of the cervical portion of the vertebral column, where it extended across the cervicothoracic junction. The attachments of the longus capitis muscle onto the transverse processes of C2, C3, C4, and C5 and of the scalenus ventralis muscle onto the transverse processes of C5, C6, and C7 were removed. During this process, a distinct interdigitation was detected between the longus capitis and scalenus ventralis muscles on the transverse process of C5. The intertransversarius muscle was left intact on the lateral aspect of the cervical portion of the vertebral column. Both the left and right sides of each anatomic specimen were dissected to evaluate symmetry of muscular architecture and morphology.

Results

Multifidus cervicis and multifidus thoracis muscles—The multifidus cervicis muscle was identified deep to the ventral portion of the semispinalis capitis muscle and adjacent to the lamellar portion of the nuchal ligament between C2 and C4. Cranial to C4, the multifidus cervicis muscle was lateral to the cervical portion of the spinalis cervicis muscle. The multifidus cervicis muscle covered the dorsolateral aspect of the cervical vertebrae from C2 to C6 where it merged seamlessly into the multifidus thoracis muscle. Five bundles were identified at each vertebral level, and their attachments were consistent in all anatomic specimens. The bundles were arranged into 3 layers (lateral, medial, and deep) in accordance with their cranial and caudal attachments and the architectural divisions used to describe the morphology of the multifidus muscle in humans[23] and dogs.[24] Each bundle attached cranially to a vertebral spinous process and caudally onto the lamina of a vertebral body and the joint capsule of an APA, with the exception of the most cranial attachments at C2, where the lateral and medial layers interdigitated with tendinous fibers of the obliquus capitis caudalis muscle arising from the caudolateral aspect of the vertebral spinous process. The various attachments at this level were adapted to the atypical morphology of C2, compared with the other cervical vertebrae, and to the extensive attachment of the nuchal ligament over the vertebral spinous process.

The lateral layer of the multifidus cervicis muscle consisted of 2 bundles (superficial and deep) on each side that attached cranially to the lamina of the dorsal aspect of a vertebra then diverged from the midline in a caudolateral direction; each successive pair of muscle bundles filled the V-shaped gap between the more cranial bundles. The superficial muscle bundle of the lateral layer crossed 3 intervertebral joints before attaching caudally on the dorsolateral aspects of the vertebral lamina and dorsocranial aspect of the APA joint capsule with short tendons (**Figure 1**). The deep bundle of the lateral layer crossed 4 intervertebral joints; this was the longest bundle of the multifidus cervicis muscle. The cranial attachment to the vertebral spinous process was

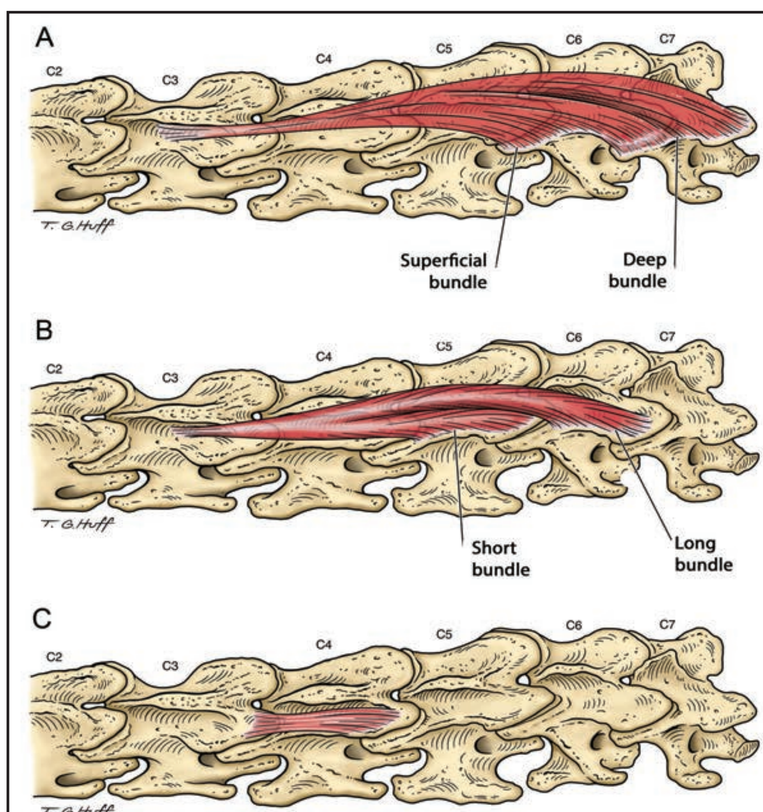

Figure 1—Illustrations of dorsolateral oblique views of the multifidus cervicis muscle in the cervical region of the vertebral column of a horse. A—Illustration of the lateral layer of the muscle indicating the cranial and caudal attachments of the superficial and deep muscle bundles. B—Illustration of the medial layer of the muscle indicating the cranial and caudal attachments of the short and long muscle bundles. C—Illustration of the deep layer of the muscle indicating cranial and caudal attachments.

by means of a strong tendon that fanned into the muscle belly as it coursed toward its caudal attachment on the dorsocranial aspect of the APA joint capsule with several short tendons. The 2 bundles of the lateral layer were separated cranially by a wide flat tendon that extended along the length of the muscle belly of the longest bundle. Caudally, a separate tendon was visible on the dorsal side of the muscle belly that was not continuous with the cranial tendon. Throughout their length, fibers from the 2 bundles of the lateral layer interdigitated with each other and also attached onto the superficial tendon of the more caudal bundles. Superficial bundles from multiple levels conjoined into the tendinous attachment over the APAs and the fibrous bands covering the dorsolateral aspects of lamina that bridged adjacent APAs.

The medial layer of the multifidus cervicis muscle consisted of a short and long bundle, which extended across 2 and 3 intervertebral levels, respectively (Figure 1). The 2 bundles had a common muscular and tendinous cranial attachment on the spinous process of the vertebral body, ventromedial to the cranial attachments of the lateral layer, and a caudal attachment on the lamina of the vertebral body and dorsocranial aspect of the APA joint capsule. The musculotendinous units of the medial layer were shorter than those of the lateral layer and had more muscle fibers attaching directly into the fibrous capsules of the APAs. The tendon forming the common cranial attachment for the 2 bundles of the medial layer continued into the muscle belly, forming a partial separation between them.

The deep layer of the multifidus cervicis muscle consisted of 1 bundle that crossed a single intervertebral joint, spanning the distance between adjacent APAs and filling the concavity on the dorsolateral aspect of the lamina (Figure 1). It had tendinous attachments on the dorsal aspect of successive APA joint capsules, together with muscle fibers that inserted directly into the fibrous band that bridged the length of the lamina on its lateral aspect.

As the vertebrae became shorter in the caudal aspect of the cervical portion of the vertebral column, the absolute length of the bundles of the multifidus muscle became correspondingly shorter and there was less difference in length between the bundles of the lateral and medial layers, especially caudal to C5. The attachment pattern of the 5 bundles of the multifidus cervicis muscle was maintained across the cervicothoracic junction, but their orientation changed in accordance with the elongation of the thoracic vertebral spinous processes to form the withers (most dorsal aspect of the shoulders). The multifidus thoracis muscle continued caudally along the thoracic portion of the vertebral column as described by Stubbs et al.[25] The change in relative lengths of the fibers in the various muscle bundles became most evident caudal to C5. Despite the close proximity of the multifidus muscle to the intertransversarius dorsalis muscle, no direct interdigitations were found, and the 2 muscle groups were separated by a fibrous band overlying the lateral aspect of the vertebral lamina. The observed anatomic CSA of the multifidus cervicis muscle was smallest at its cranial attachment at C2, increased to a uniform size from C3 to C5, and then became thinner and flatter in the caudal cervical and cranial thoracic regions, where it attached to the long vertebral spinous processes.

Longus colli muscle—The longus colli muscle was located at the ventrolateral aspect of the vertebral bodies on each side, from the atlanto-occipital joint to T5 or T6. It was deep to the longus capitis muscle in the cranial part of the neck and the scalenus ventralis muscle caudally, with the trachea and esophagus overlying the muscle ventrally. In the cranial thoracic region, the longus thoracis muscle was surrounded ventrally by the aorta, pleura, and viscera, up to and including its most caudal attachment at the level of T5 or T6. Five bundles of the longus colli muscle originated at each vertebral level from C1 to C5, each of which had a cranial attachment on the ventral surface of the vertebral body, then diverged laterally toward their caudal attachment to a transverse process of a more caudal vertebra as far caudally as C6. Bundles arising from the occiput to C1 also had direct musculotendinous attachments to the ventral aspect of the joint capsules of the APAs. Caudal to C6, the caudal attachments were to the medial aspect of the joint capsules of the costovertebral joints and to the ventral longitudinal ligament where it crossed over the thoracic intervertebral symphyses. The part of the longus colli muscle originating from C6 and extending caudally had a well-defined muscle belly without fascicular subdivisions.

On the basis of the fascicular attachments in the cervical portion of the vertebral column, the longus colli muscle was divided into ventral, medial, and deep layers. The ventral layer consisted of 2 bundles, both of which had a strong cranial tendon that attached onto the ventral crest. The more superficial bundle of the ventral layer crossed 3 intervertebral joints before attaching with direct muscle fiber insertions interspersed with tendinous fibers onto the ventrocaudal aspect of the transverse process (**Figure 2**). The medial bundle of the ventral layer was the longest muscle bundle of the longus colli muscle. It spanned 4 intervertebral joints from a strong tendon at its cranial attachment on the ventral crest to its caudal attachment on the lateroventral aspect of the transverse process with a musculotendinous insertion. From C1 to C5, long thin muscle bellies of the 2 bundles of the ventral layer of the longus colli muscle were separated by a fascial septum. Superficial bundles of the ventral layer of 1 vertebral level interdigitated with those of the more caudal ventral layers and with tendinous fibers of bundles of the medial layer.

The medial layer of the longus colli muscle consisted of 2 bundles (short and long) with cranial attachments on the ventral crest, medial to the attachments of the fibers of the lateral layer, and with caudal attachments on the medioventral aspect of the transverse process, medial to those of the lateral layer (Figure 2). The short and long muscle bundles spanned 2 and 3 intervertebral levels, respectively, and compared with bundles of the lateral layer, had shorter muscle bellies with longer tendons that extended further into the muscle belly. The longer (and deeper) of the 2 bundles of the medial layer had a predominantly muscular cranial attachment, whereas the shorter (and more superficial)

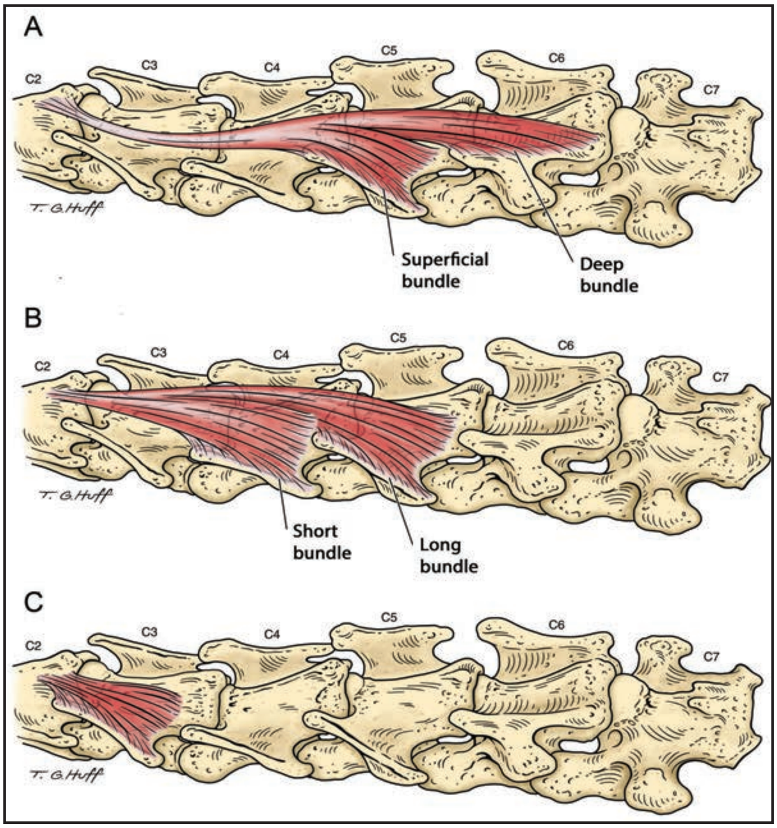

Figure 2—Illustrations of ventrolateral oblique views of the longus colli muscle in the cervical region of the vertebral column of a horse. A—Illustration of the ventral layer of the muscle indicating the cranial and caudal attachments of the superficial and deep muscle bundles. B—Illustration of the medial layer of the muscle indicating the cranial and caudal attachments of the short and long muscle bundles. C—Illustration of the deep layer of the muscle indicating cranial and caudal attachments and muscle bundles.

bundle was tendinous with the tendons also inserting on the fibrous band between the cranial and caudal parts of the transverse process of a vertebra. A distinct fibrous band spanned the distance between the cranial and caudal parts of the transverse processes of each cervical vertebra from C3 to C6 and served as a location for musculotendinous attachment.

The deep layer of the longus colli muscle consisted of 1 bundle that spanned a single intervertebral joint with a muscular cranial attachment onto the lateral aspect of the ventral crest (medial to the cranial attachments of the medial layer) and a tendinous caudal attachment onto the ventromedial aspect of the transverse process of the adjacent vertebra. The bundle had many tendinous septa interspersed with fleshy muscle fibers. It filled the concavity on the ventral aspect of the vertebral body, between the midline and the transverse process (Figure 2).

No distinct fascial separation was detected between the longus colli and intertransversarius muscles in the cervical portion of the vertebral column. The attachments of the intertransversarius ventralis cervicis muscle to the dorsal aspect of the transverse process interdigitated medially with those of the superficial layer of the longus colli muscle, and fibers from both muscles attached on the fibrous band that extended across the transverse process.

The multiple muscle bundles of the longus colli muscle were repeated in a segmental manner with cranial attachments from C1 to C5; caudal to that, it continued as the longus thoracis muscle. A single deep bundle was observed in the ventrolateral concavity of the vertebral body of C7. This bundle had cranial and caudal musculotendinous attachments extending laterally from the tendon at the caudal aspect of the ventral transverse process of C6 to an attachment onto the craniomedial aspect of the costovertebral joint at C7-T1. This bundle did not attach directly to the transverse process at C7 but filled the concavity directly ventral to the transverse process.

From C6 caudally, the longus thoracis muscle was a single fusiform muscle belly with parallel fibers that filled the concavity on the ventral aspects of the vertebrae as far caudally as T5 or T6 (**Figure 3**). It attached to C6 with a thick, strong tendon at the ventromedial part of the transverse process, without direct or superficial attachment to the transverse process of C7. The tendon became embedded within the muscle belly, then became gradually more difficult to identify until it could not be detected by the level of T2. Short thick musculotendinous fibers connected the lateral aspect of the muscle to the craniomedial aspect of the fibrous capsules of the costovertebral joints. There were muscular attachments to the ventral aspect of the vertebral bodies and musculotendinous insertions onto the ventral longitudinal ligament where it spanned the intervertebral symphyses. The ventral longitudinal ligament was thickest over the intervertebral symphyses and consisted of only a few indistinct thin fibers where it crossed the intervening vertebral bodies.

The observed combined anatomic CSA of the 5 muscle bundles of the longus colli muscle was smallest from C1 to C3, increased from C3 to C5, and then decreased markedly. In the thoracic region, the anatomic CSA of the longus thoracis muscle increased from T2 toward the caudal attachment, where it decreased abruptly.

In the cervical region, the muscle fibers of the multifidus and longus colli muscles were orientated in a craniomedial to caudolateral oblique angle to the long axis of the vertebrae, with the obliquity increasing in the deeper fibers. The lateral and medial layers had long muscle bellies that extended across multiple vertebral segments, whereas the deepest layer had the shortest, most oblique fibers, spanning only 1 intervertebral joint.

Discussion

In this study, the gross anatomy of the sagittal deep stabilizing musculature of the cervical and cranial aspect of the thoracic portion of the vertebral column in horses was determined. The results indicated that

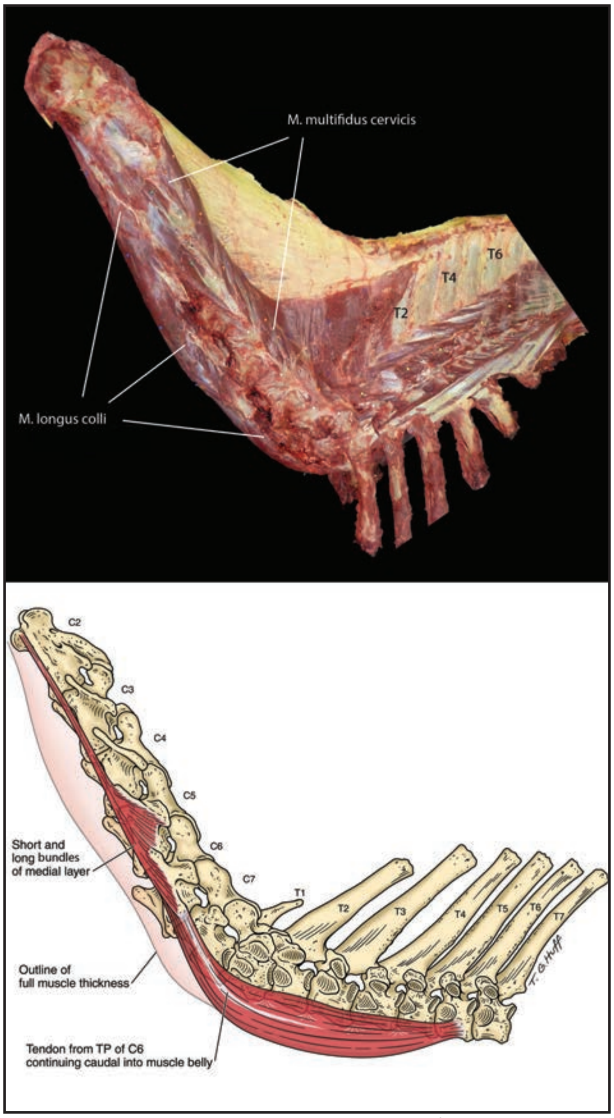

Figure 3—Photograph (A) and illustration (B) of the lateral aspect of the cervical and cranial aspect of the thoracic region of the vertebrae in an anatomic specimen of a representative horse. A—Photograph of a dissected anatomic specimen indicating the longus colli and the multifidus cervicis muscles. B—Illustration indicating the anatomic locations of the longus colli and longus thoracis muscles. The lightly shaded outline indicates the area occupied by the cervical part of the muscle. The position of the muscle belly of the longus thoracis muscle in the cervicothoracic junction is shown. TP = Transverse process.

characteristics of the multifidus cervicis and longus colli muscles were consistent among horses regarding the number of bundles and their attachment sites onto the vertebrae. The longus colli and multifidus cervicis muscles had 5 bundles for each vertebral segment from C2 through C6 on the dorsal and ventral aspects, respectively, of the vertebrae, which is the same as the arrangement of these muscles in humans.[18,21,22] Caudal to C6, the multifidus thoracis muscle maintained its multifascicular pattern but had changes in fiber orientation to accommodate the elongation of the spinous processes in the thoracic region. The longus colli muscle was continued caudally by a single muscle belly extending from C6 to T5-T6, with intermediate attachments to the ventral longitudinal ligament overlying the intervertebral disks, where it likely acted to stabilize the joints, and into the joint capsules of the medial costovertebral articulations from T1 to T4-T5.

Functionally, muscles with long, parallel fibers and a small physiologic CSA are primarily designed for large excursions and fast velocities of contraction and movement, whereas muscles with short, pennate fibers and large physiologic CSA are better suited to create large forces.[26] In horses, the long neck is suspended in an approximately horizontal orientation and requires muscles with long, parallel fibers and muscles with short, pennate fibers attached to all aspects of the vertebrae to facilitate and control motion and stability.

The long superficial muscles of the neck affect numerous intervertebral joints simultaneously and have an effect on the entire neck rather than having a specific effect on localized areas. Therefore, a series of short, deep cervical muscles are required to provide localized changes in neck movement and shape and to stabilize individual intervertebral joints. The multifascicular multifidus cervicis and longus colli muscles may have such functions. Stratification of the deep cervical musculature provides simultaneous control of mobility and stability of vertebrae in humans[27]; results of the present study of horses were similar. The long, thin muscle bellies and short tendinous attachments of the superficial muscles are likely to contribute to multisegmental movement, whereas bundles of the deep muscles spanning single intervertebral joint segments may primarily provide intersegmental stability. Results of another study[28] in which the moment arms of individual muscle bundles were calculated confirmed that superficial muscle bundles are mechanically adapted to produce localized changes in back shape, whereas deep bundles are better suited to provide stability of intervertebral joints. The anatomic CSA of the multifidus thoracis and multifidus lumborum muscles seemed to increase caudally in the anatomic specimens of horses evaluated in that study, and was largest at the lumbosacral junction; this may indicate a need for a high amount of stabilization in this area where severe osseous pathological changes commonly occur.[29] In the cervical and cranial aspect of the thoracic portion of the vertebral column, the anatomic CSA of the multifidus and longus colli muscles seemed to be greatest in the midcervical region (C3-C5), which is also an area with a high prevalence of osseous degenerative lesions in horses.[a]

In humans with neck pain, the direct attachments of the multifidus muscle onto the APAs of the cervical portion of the vertebral column and the resulting tension or shearing of mechanoreceptive and nociceptive nerve endings in the joint capsules are directly linked with altered proprioception and dysfunction.[30,31] Tension on the synovial folds in the APAs is also a contributory factor to neck pain in humans[30]; estimated loads as high as 51 N are applied to the capsules of facet joints by the musculature.[32] Those similarities between humans and horses regarding attachments of the equine multifidus cervicis muscle and the finding of another study[33] that cervical vertebral APAs of horses have synovial folds[33] suggest that sources of cervical pain in humans and horses may be similar. Cervical proprioceptive changes lead to altered recruitment patterns of deep stabilizing musculature in humans[34,35]; on the basis of similarities in arrangement of the multifidus cervicis muscles in horses, we suggest that forces exerted by these muscles on the APAs are essential for dynamic stabilization and postural stability and that dysfunction of these muscles is involved in the etiopathogenesis of cervical vertebral pain in horses. This may be an important finding for determination of associations among signs of neck pain, loss of intersegmental dynamic stability, proprioceptive deficits, and compromised neuromotor control in horses.

In humans, the longus colli muscle has been described as a prevertebral muscle divided into anterior, superior, and oblique layers with direct fascicular attachments from the vertebral bodies and the transverse processes of the second or third thoracic vertebrae (there is variation among individuals) to the anterior arch of the atlas.[18,36,37] Results of studies of muscle recruitment patterns in healthy humans indicate the function of the longus colli muscle is flattening of cervical lordosis and provision of intersegmental joint stability[38] as well as segmental coactivation with the longus capitis muscle in craniocervical flexion.[19,37] However, the predominantly vertical orientation of the neck in humans is associated with different static and dynamic forces, compared with the more horizontal orientation of the neck in horses; therefore, direct comparisons cannot be made between these species. The primary function of the longus capitis muscle seems to be flexion in the cranial aspect of the cervical region[38] with synergistic action from the longus colli muscle to flatten lordosis in the cranial aspect of the cervical region. In the anatomic specimens of horses in the present study, longus capitis and longus colli muscles had common attachments at C2, C3, and C4, which suggested those 2 muscles may share common synergistic functions of simultaneous facilitation of dynamic motion and passive support in the cranial aspect of the cervical region of horses (where the vertebral column is orientated more horizontally than it is in other locations). In humans, the longus thoracis muscle terminates around T3, whereas the most caudal attachment of the segmental part of the longus thoracis muscle in anatomic specimens of horses was to the transverse processes of C6; this finding may have been attributable to the greater number of thoracic segments in horses, compared with that in humans. Caudal to that location, a strong muscle with parallel fibers that had a well-developed tendon continued caudally ventral to the first 5 or 6 thoracic vertebrae (representing the hypaxial musculature). Between T6 and T15, there was no direct attachment of the hypaxial musculature to the vertebral bodies.

The finding of the present study of multiple muscle bundles of the equine multifidus cervicis and longus colli muscles was consistent with a function of providing dynamic segmental stability and support in the cervical portion of the vertebral column in horses. The multifidus muscle maintained the same anatomic arrangement and attachment characteristics from the cervicothoracic junction to the thoracic portion of the vertebral column. The multifascicular pattern of the longus colli muscle in the cervical region changed to a single, well-defined muscle belly that extended from C6 to T5-T6 in the cranial aspect of the thoracic region and was reinforced by a strong tendon that appeared to support the ventral aspect of the vertebral curvature in the cervicothoracic region. Effective stabilization by the deep perivertebral muscles may reduce the risk of osteoarthritis and development of neck pain in horses, which is a limiting factor for performance of such animals.

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