Dorsal origin of the cutaneus trunci muscle in the rat, with special reference to the tail attachment

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Dorsal origin of the cutaneus trunci muscle in the rat, with special reference to the tail attachment

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Abstract

PURPOSE: This study aimed to describe the dorsal origin of the cutaneus trunci muscle (CTM) especially focusing on the attachment manner to the tail. METHODS: Five Wistar rats were dissected and the configuration of the CTM was observed macroscopically. RESULTS: The CTM consisted of the humeroabdominalis muscle (HAM) and humerodorsalis muscle (HDM). The dorsal origin of the HDM was divided into three parts: scapular, intermediate, and caudal. The muscle fibers which attached to the tail were derived from the caudal part. They attached to the spinous process and transverse process of the coccygeal vertebra, dorsal coccygeal fascia, and intervertebral ligament at the Co3-Co4 level. CONCLUSION: The results show robust attachment of the CTM to the vertebra, fascia, and ligament of the base of tail in the rat. The prior knowledge about the tail attachment of the CTM is thought to be beneficial to the improvement of experimental technique dealing with animal skin and its evaluation.

Key words: laboratory animal, skin, gross anatomy, cutaneus trunci muscle, attachment to tail

Introduction

The skin wound including pressure ulcer is an important issue that nurses and physicians are often faced in the clinical setting. Pursuing better wound healing, many experimental challenges have been conducted using animal model[1-5]. Except for the human, most mammals possess the cutaneus trunci muscle (CTM), also known as the subcutaneous trunk muscle or cutaneus maximus muscle, whose function is generally explained as tensing and moving the skin of the trunk. It covers almost the entire wall of the thorax, abdomen, and back. The morphological development of the CTM varies widely from species to species. Then, it would be a troublesome matter for not a little researcher in dissecting process. Nevertheless, the morphology of the CTM in the rat which is the most commonly used laboratory rodents has been roughly described or briefly reported[6-8]. Even now, it is unclear how far the CTM extends caudally in the rat.

The CTM is a vulnerable tissue at the skin experiment due to its superficial location and spreading arrangement. It is conceivable that the anatomical knowledge about the CTM is necessary to eliminate the negative effect of the unintended damage to the CTM. In general, the CTM in the dorsal surface of the trunk is more subjected than in the ventral one on account of its broadness and viewability at such experiments. Therefore, the aim of this study was to describe the dorsal origin of the rat CTM especially focusing on the attachment manner to the tail.

Materials and Methods

The animals used were five Wistar rats (four males and one female) of 8 weeks of age. At the outset, they were sacrificed for the control experiment of cerebral arteries by Dr. S.

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Okuyama[9]. After that, the dead bodies were handed us from him in 2004 for exhaustive utilization of animal resources. Immersed in 10% formalin solution for enough fixation, the dermis was excised, the adipose tissue was removed, and the CTM was macroscopically observed. The anatomical nomenclature of muscles followed Nomina Anatomica Veterinaria Japonica[10] and Ura's classification[11]. The cross-sectional image of the rat tail was referenced from the figure of Hori et al.[12]

The study was performed pursuant to the experimental protocol of the Institutional Animal Care and Use Committee of Kagoshima University (No. M08015).

Results

Gross anatomy of the CTM

At first, general configuration of the CTM was confirmed. The findings were almost common to the examined rats. The CTM of the rat consisted of the humeroabdominalis muscle (HAM) and humerodorsalis muscle (HDM). The HAM arose from the median abdomen and the integument around the external genital organ, while the HDM had broad origin in the lateral and dorsal surface of the trunk as well as the lateral thigh (Fig.1). Due to the intermingling of muscular bundle, discrimination between these muscles was impossible in the origin side. They ran parallel beneath the pectoralis profundus muscle cranialward, and finally attached to the shaft of humerus with separated insertion. The CTM was innervated by the caudal pectoral nerve composed of the 7th cervical to 1st thoracic segments derived from the brachial plexus. The nerve arborized caudalward and the fine branches entered the CTM.

Dorsal origin of the HDM

According to the craniocaudal level and muscular fiber course, the origin of the HDM in the dorsal surface was divided into three: scapular, intermediate, and caudal parts (Fig.1). The muscle fibers of scapular part coursed vertically to the spinal column. In the dorsal midline between the right and left scapulae there was a distinct interlacing of the fibers with those from the contralateral side. The fibers of intermediate part arose from the deep external fascia of the trunk near midline and coursed obliquely toward the axilla. Thus a narrow defect of the cutaneous muscle was found at the midst of the back. The fibers of caudal part coursed obliquely located caudolateral to the intermediate part. It did not extend beyond the midline. Among three parts of the dorsal HDM, only the caudal part made attachment to the tail.

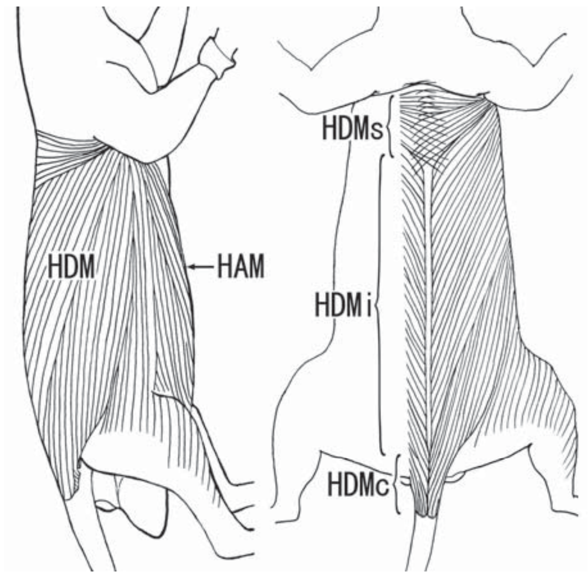

Fig.1 Schematic sketches showing the cutaneus trunci muscle of a male rat (lateral and dorsal view). HAM, humeroabdominalis muscle; HDM, humerodorsalis muscle. The boundary between these muscles is ambiguous in the origin side. In the dorsal view, three parts of the HDM are shown: HDMs, scapular part; HDMi, intermediate part; HDMc, caudal part.

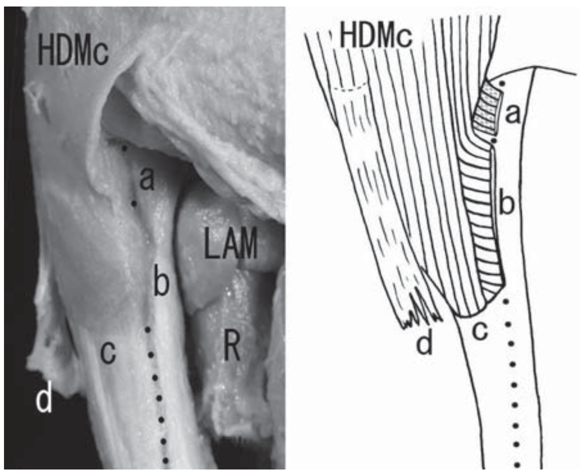

Fig.2 A photograph and its schematic drawing of the HDM's attachment to the base of tail (right dorsolateral view). HDMc, caudal part of the humerodorsalis muscle; LAM, levator ani muscle; R, rectum; a, cranial twisting slip; b, main muscular bundle attaching to the transverse process and intertransverse ligament; c, muscle fibers attaching to the dorsal coccygeal fascia; d, thin slip to tail dermis. Dotted line indicates the boundary between the ventral and dorsal coccygeal muscles.

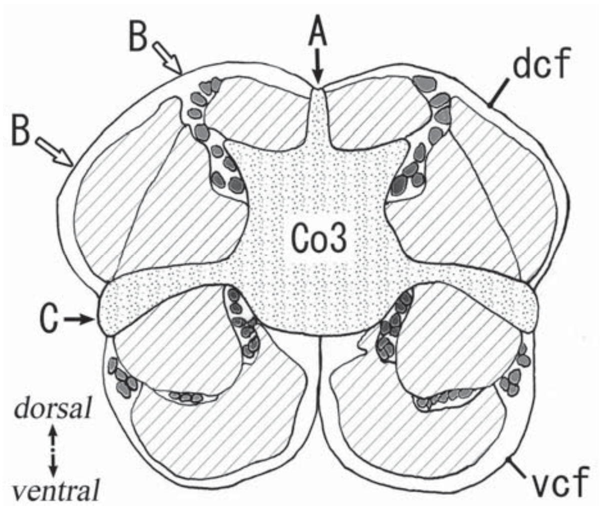

Fig.3 Cross-sectional image at the 3rd coccygeal vertebra (Co3) modified after Hori et al.[12] A and C, bony attachments; B, fascial attachment; dcf, dorsal coccygeal fascia; vcf, ventral coccygeal fascia. Shaded areas and filled circles in black show sections of the tail muscles and their tendons, respectively.

Attachment manner to the tail

The robust origins of the caudal part were identified on the coccygeal vertebra, coccygeal fascia, and intervertebral ligament at the base of tail, whereas a sparse and thin slip directing the tip of tail diffused away to the dermis (Figs.2 and 3). On the midline, the caudal part of the HDM attached intensively to the spinous process of the 3rd coccygeal vertebra (Co3). It extended along the supraspinous ligament until the spinous process of the Co4. Apart from the midline, the muscle fibers were connected to the outer surface of the dorsal coccygeal fascia which enveloped the dorsal coccygeal muscles and their tendons in block (Fig.3). In the lateral aspect, this fascia was fixed to the tip of the transverse process of coccygeal vertebrae and intertransverse ligaments. Together with the coccygeal fascia, the caudal part of the HDM attached to the transverse process and ligament at the Co3-Co4 level (Fig.2). The most cranial slip participating in the lateral attachment seemed to take unique course. It was split off from the deep surface of the caudodorsal margin of the HDM and twisted before reaching to its attachment at the boundary between the ventral and dorsal coccygeal muscles (Fig.3). The lateral caudal artery/vein and caudal nerve trunk together came out from the pelvic deep portion and descended near the lateral attachment toward the tip of tail. In 6 sides of the cases, they penetrated the muscle between the caudal main bundle and cranial twisting slip, while in 4 sides they passed superficial to the whole muscle fibers (Fig.4).

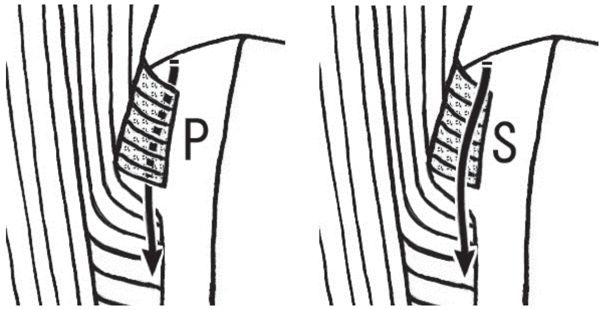

Fig.4 Schematic drawing showing two types of course (arrows) of the lateral caudal vessels and caudal nerve trunk. In the P-type (left) they penetrate the muscle between the cranial thin slip and main muscular bundle, while in the S-type (right) they pass superficial to the whole muscle fibers.

Discussion

The CTM has been utilized in a wide range of investigations, e.g. neurophysiological analysis of the spinal reflex[13,14], nerve regeneration[15], validation of myocutaneous flap[16], and phylogenetic differentiation in mammals[11]. Presumably, the main reasons for adopting it are superficial location, broad surface with mantle-like shape, monophyletic innervation, and segmental perforation of the nerves and vessels to the dermis. These characteristics let the identification of muscle easy and make the long striated muscular bundle accompanying nerves and vessels available. In such studies, the CTM is definitely a main subject or material. However, these advantages change into disadvantages in a model experiment which targets the other cutaneous or subcutaneous components. Because the CTM does not appear in the human, it is an unwanted component against the artificially induced pressure ulcer[1-3] or biofilm testing[4,5].

In this study, the origins of the CTM in the rat were confirmed not only in broad dermis but on the coccygeal vertebra, intervertebral ligament, and coccygeal fascia at the base of tail. It means that the CTM has bony attachment in both origin and insertion like general skeletal muscles. Accordingly, we think that the CTM of the rat probably acts in flexion of the trunk as well as in tensing or moving the skin. Viewing the robust attachment of the caudal part of HDM, it is reasonably considered that it contributes to tension of the base of tail and stabilization during tail movement. A prior knowledge that the CTM attaches firmly to the tail would be significant in the process exposing the subcutaneous structures and making musculocutaneous flaps near the tail diminishing unintended injury.

Although all researchers know the existence of CTM, its structure is complicated beyond the common expectation as shown in this study. During the skin experiment, the CTM is often injured directly or indirectly. However, the influence on the experimental outcome by such nociceptive stimulus has not been assessed appropriately as far as the authors know. To understand the exact anatomical structure of the CTM would make contributions to the improvement of experimental technique dealing with animal skin and its evaluation. Even so, the materials examined in this study were limited to one strain of the rat. Further confirmatory study will be needed using other kinds of laboratory animals.

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References

1) Salcido R, Fisher SB, Donofrion JC, et al. An animal model and computer-controlled surface pressure delivery system for the production of pressure ulcers. J Rehabil Res Dev 1995; 32:149-161
2) Sugama J, Sanada H, Nakatani T, et al. Pressure-induced ischemic wound healing with bacterial inoculation in the rat. Wounds 2005; 17: 157-168
3) de la Garza-Rodea AS, Knaän-Shanzer S, van Bekkum DW. Pressure ulcers: description on a new model and use of mesenchymal stem cells for repair. Dermatology 2011; 223: 266-284
4) Kanno E, Toriyabe S, Zhang L, et al. Biofilm formation on rat skin wounds by Pseudomonas aeruginosa carrying the green fluorescent protein gene. Exp Dermatol 2010; 19: 154-156
5) Percival SL, McCarty SM, Lipsky B. Biofilms and wounds: An overview of the evidence. Adv Wound Care 2015; 4: 373-381
6) Greene EC. Anatomy of the Rat. Hafner Publishing: New York; 1959
7) Hebel R, Stromberg MR. Anatomy of the Laboratory Rat. Williams and Wilkins: Baltimore; 1976
8) Langworthy OR. A morphological study of the panniculus carnosus and its genetical relationship to the pectoral musculature in rodents. Am J Anat 1925; 35:283-302
9) Okuyama S, Okuyama JN, Okuyama JK, et al. The arterial circle of Willis of the mouse helps to decipher secrets of cerebral vascular accidents in the human. Med Hypoth 2004; 63: 997-1009
10) Japanese Association of Veterinary Anatomists, ed. Nomina Anatomica Veterinaria Japonica, 3rd ed. Gakuso-sha: Tokyo; 2000
11) Ura R. Über die allgemeine Differenzierung der oberflä chlichen Brustmuskeln mit besonderer Berücksichtigun g der Hautrumpfmuskeln der Säugetiere. Mitt Med Ges Tokyo 1937; 51: 216-288, 339-390
12) Hori H, Fukutani T, Nakane H, et al. Participation of ventral and dorsal tail muscles in bending movements of rat tail. Anat Sci Intl 2011; 86: 194-203
13) Theriault E, Diamond J. Intrinsic organization of the rat cutaneus trunci motor nucleus. J Neurophysiol 1988; 60: 463-477
14) Petruska JC, Barker DF, Garraway SM, et al. Organization of sensory input to the nociceptive-specific cutaneous trunk muscle reflex in rat, an effective experimental system for examining nociception and plasticity. J Comp Neurol 2014; 522: 1048-1071
15) Pan BH, Grünewald B, Nguyen T, et al. The lateral thoracic nerve and the cutaneous maximus muscle - A novel in vivo model system for nerve degeneration and regeneration studies. Exp Neurol 2012; 236: 6-18
16) Ohara H, Kishi K, Nakajima T. Rat dorsal island skin flap: A precise model for flap survival evaluation. Keio J Med 2008; 57: 211-216