【Original Article】
Bull. Sch. Health. Sci., Kagoshima Univ.
24(1):53- 56, 2014

Subcutaneous arterial arrangement in the dorsum of the house musk shrew, *Suncus murinus*

Kazuharu Mine[1)], Rie Shimotakahara[1)], Shigemitsu Ogata[2)]

[1)] Gross Anatomy Section, Kagoshima University Graduate School of Medical and Dental Sciences,
Sakuragaoka 8-35-1, Kagoshima, 890-8544, Japan
[2)] Department of Clinical Nursing, School of Health Sciences, Faculty of Medicine, Kagoshima University,
Sakuragaoka 8-35-1, Kagoshima, 890-8520, Japan

Abstract

The house musk shrew (*Suncus murinus*) was studied to uncover the arrangement of the subcutaneous arteries in the dorsum. The axial arterial tracts were obviously found on the outer surface of the panniculus carnosus bilateral to the spinal column. These tracts extended longitudinally beyond the angiosomes. The thoracodorsal artery and the deep circumflex iliac arteries were the main suppliers of the dorsal axial tract. A large number of transverse twigs from the axial tracts formed an arterial network that covered the entire dorsum. The general arrangement of the subcutaneous arteries in the dorsum of the musk shrew resembled that in the rabbit. This arrangement was considered to be closely related to the high skin mobility of musk shrews. This unique vasculature in the dorsum is one of the advantages of using *S. murinus* as an experimental model for studies focusing on the skin.

Key words: Suncus murinus, artery, skin, angiosome, animal model

Introduction

The house musk shrew (*Suncus murinus*) (Fig. 1), which is native to Southeast Asia, is a member of order Soricomorpha, formerly classified into Insectivora. In the 1970s, a line of musk shrews was established in Japan for use as a new laboratory animal[1)]. Since then, the animal has been utilized in ethological, physiological, morphological, and clinical studies[2-8)]. However, to our knowledge it is scarcely used for studies focusing on the skin, which are instead conducted using conventional laboratory animals such as the mouse, rat, and rabbit. One possible reason for this is a lack of established morphological information on the musk shrew's subcutaneous distribution of nerves, blood vessels, and other features. Such knowledge of the subcutaneous architecture of a laboratory animal is crucial for experimental procedures such as planning a skin-flap or musculocutaneous flap, creating an artificial pressure ulcer, evaluating wound healing, and understanding dermal carcinogenesis. Systematic detailed descriptions of musk shrew anatomy have been made by Sharma[9)] for the wild Indian subspecies and by Isomura[10)] for the Japanese laboratory subspecies. However, these studies did not fully characterize the subcutaneous morphology.

It is well known that the skin of the musk shrew has pronounced mobility compared with traditional laboratory animals. This characteristic allows the animal to be used as an alternative model for relatively large-scale experiments focusing on the skin, such as preparing a dorsal skinfold chamber[11,12)] and implanting metal filler[13)].

Before initiating a full-scale evaluation of the suitability

Fig.1 A male adult musk shrew, alive in the housing facilities.

Correspondence to Kazuharu Mine
Phone: 099-275-6112 Fax: 099-275-6118
E-mail: mine@dent.kagoshima-u.ac.jp

of this animal as a model species for specific experiments of the skin, basic information about its subcutaneous tissue must be accumulated. The aim of the present work is to clarify the general arrangement of the subcutaneous arteries in the dorsal trunk, a common target location for skin experiments, in *S. murinus* and to compare it with that in other selected animals including humans.

Materials and methods

Animals:

Twelve adult shrews (10 males and 2 females) were dissected to examine their vasculature. Shrews were provided by Dr. Yamanaka of the Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima University, who has maintained a closed breeding colony of *S. murinus* for odontogenetic study. We opted to use these shrews to ensure effective use of animal resources because the shrews would have been culled for control of breeding numbers. The colony consisted of descendants of the Jic:CR strain from the Central Institute for Experimental Animals (Kawasaki, Japan). The experimental protocol was approved by the Institutional Animal Care and Use Committee of Kagoshima University (Approval Number M08015). The nomenclature of the vessels and muscles used herein conforms to that listed in the *Nomina Anatomica Veterinaria Japonica*[14].

Dissection procedure:

The animals were anesthetized with ether and then given an intraperitoneal injection of 5% chloral hydrate solution. After the animal was completely narcotized, the thoracic cavity was opened. To increase visibility of the arteries against other soft tissue, colored latex solution was injected into the left ventricle of the heart using a disposable syringe after perfusion with saline. Specimens were soaked in 10% formalin solution at room temperature for least 3 months. After sufficient fixation, they were decorticated at the depth between the corium and panniculus carnosus muscle (PC) except on the snout and distal extremities. Thereafter, the distribution of subcutaneous arteries in the dorsal trunk was observed and recorded by line drawing and photography. Recordings were made using the unaided eye and a dissecting microscope when necessary.

Results

The general arrangement of the arterial system superficial to the PC was first examined, then the origin of the superficial branch was pursued retrogradely. Several arterial branches were found to emerge in the outer surface of the PC, some of which were aligned alongside the spinal column bilaterally and formed the axial tracts (Fig. 2). These superficial arterial links were mainly supplied by the dominant cutaneous branches emerging between the right and left scapulae and in the loin. The emerging branches were derived from the source arteries under the PC. The source arteries bifurcated, piercing the PC and running cranially and caudally (Fig. 3). An anastomotic connection existed between the cranial and caudal branches on the outer surface of the PC. In 5 specimens, the anastomoses were thick and a long axial arterial tract ran continuously from the neck to the base of the tail (Fig. 2). In 7 specimens, the anastomoses instead consisted of some fine twigs and the axial tract appeared on the outer surface of the PC intermittently. Even so, the tract continued indirectly under the PC through the source artery. The arterial arrangement was essentially symmetrical bilaterally. No sex differences were observed.

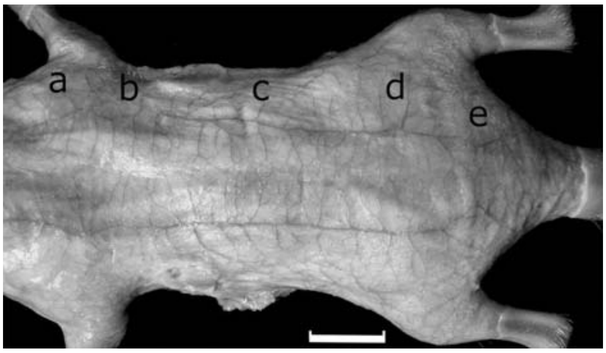

Fig.2 Photograph showing the main arterial distribution in the dorsal trunk. At the points from a to e, the cutaneous branches are continuous with the axial tract. Source arteries: a, superficial cervical artery; b, thoracodorsal artery; c, dorsal intercostal arteries; d, deep circumflex iliac artery; and e, caudal gluteal artery. Scale bar 1 cm.

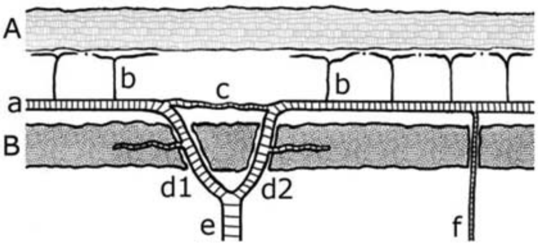

Fig.3 Schematic diagram of subcutaneous arterial course. A, corium and epidermis; B, panniculus carnosus; a, axial arterial tract; b, terminal cutaneous twigs; c, anastomosis between cranial and caudal branches; d1, cranial branch; d2, caudal branch; e, source artery (e.g., thoracodorsal artery); f, direct perforating artery (e.g., dorsal intercostal artery).

The source artery for a tract at the scapula level was the thoracodorsal artery. It initially arose from the subscapular artery, and coursed along the axillary border of the scapula. After supplying the latissimus dorsi muscle and the circumscapular adipose tissue, the cutaneous branch of the thoracodorsal artery reached the deep layer of the PC. The source artery at the loin was a continuation of the deep circumflex iliac artery. It initially arose from the external iliac artery at the point proximal to the inguinal ligament, and coursed laterally along the caudal end of the abdominal wall. The artery then passed through the hiatus between the quadratus lumborum muscle and the obliquus externus abdominis muscle to appear in the extra-abdominal space. At this point the artery divided to form the proximal cutaneous branch to the dorsum, which participated in the axial tract. The remainder curved medially and gave off the distal cutaneous branches supplying the sides of the body and ventral trunk (Fig. 4). It terminated supplying the inguinal adipose tissue.

From the axial arterial tract, many twigs were given off medially and laterally in a direction perpendicular to the body axis, spreading across the entire dorsal trunk. Medially directed twigs anastomosed with their contralateral counterparts and formed a ladder-like arterial network that covered the mid-dorsal region. Laterally directed twigs anastomosed with the cutaneous branches originating from the caudal circumflex humeral, lateral thoracic, and deep circumflex iliac arteries. The axial tract extended directly or indirectly to the cutaneous branch of the superficial cervical artery in the neck and to the cutaneous branch of the caudal gluteal artery in the buttock. The dorsal branches of the dorsal intercostal artery joined the axial tract accompanying the dorsal branches of the intercostal nerve. However, the branches were uniformly thin and appeared to supply the dorsal skin to a very limited extent.

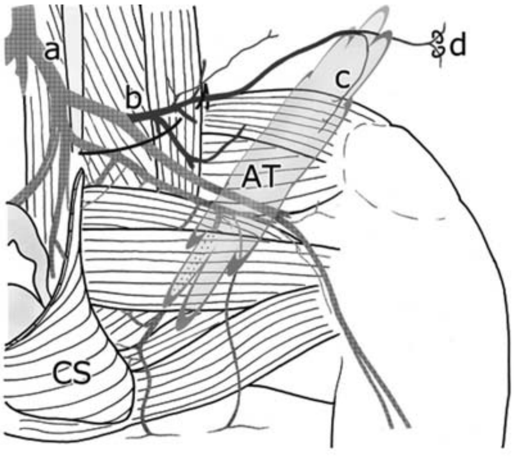

Fig.4 Schematic drawing (ventral aspect) of ramifications of the deep circumflex iliac artery. AT, inguinal adipose tissue; CS, cremasteric sac; a, common iliac artery; b, initial segment of the deep circumflex iliac artery; c, distal cutaneous branch; d, proximal cutaneous branch to the dorsum.

Discussion

In this study, we found that the musk shrew possessed an axial arterial tract in the dorsal trunk, even though its longitudinal continuity varied within a small range among specimens. The main source arteries of the tract were the thoracodorsal artery at the scapular level and the deep circumflex iliac artery in the loin. Many transverse twigs from the axial tract formed an arterial network that covered the dorsal trunk and were connected with the cutaneous branches in adjacent areas. The dorsal intercostal arteries did not substantially contribute to the arterial supply to the skin.

Based on exhaustive anatomical studies, Taylor[15)] proposed the angiosome concept for clinical application, especially for the design of musculocutaneous flaps. The angiosome is defined as a block of integument and underlying deep tissue that is supplied by the same source vessels. Taylor described over 40 angiosomes throughout the body according to arterial and venous territories. As a pilot study, Taylor and colleagues[16)] later conducted a comparative study of the vasculature of the integument and underlying deep tissues in a range of mammals. Their study revealed a marked dissimilarity of the overlying cutaneous vessels among mammalian species, and the size and density of the cutaneous perforating branches was closely related to the degree of skin mobility. Animals with mobile skin had large, long, and sparse vessels while those with fixed skin had smaller and more densely grouped vessels. Rabbit and pig specimens represented the loose and fixed extremes, respectively, whereas human, monkey, and rat specimens showed intermediate or mixed characteristics[16)].

The arterial arrangement of the musk shrew closely resembles that of the rabbit. Both species have very loose skin, implying that the development of the PC has an effect on the arterial arrangement. Among the animals examined by Taylor[16)], only the rabbit lacks an angiosome corresponding to the dorsal intercostal artery, a fact that corresponds to the poor arterial distribution of those arteries in the subcutaneous layer. Taylor characterized that the “connection between adjacent cutaneous arteries is by either true anastomoses, without change in caliber, or by reduced-caliber choke anastomotic vessels"[17]. In the musk shrew, true anastomoses were typically found between the longitudinal cutaneous branches of the thoracodorsal artery and the deep circumflex iliac artery. These anastomoses formed the continuous axial tract and extended beyond the angiosome. Choke anastomoses were plentiful in the integument of the whole dorsum, including the median connection of medially directed transverse twigs with contralateral ones.

Thus, *S. murinus* has a subcutaneous arterial arrangement corresponding to the rabbit type as identified by Taylor. The axial tract extends beyond the angiosomes and is suited for relatively long musculocutaneous flaps. These qualities, taken together with the fact that the musk shrew is smaller than the rabbit and mates more readily, suggest that the musk shrew is a more advantageous animal model for studies of the skin and subcutaneous tissues. Subsequent evaluations of the musk shrew should be designed in consideration of their subcutaneous vasculature.

Conclusion

S. murinus has a dorsal subcutaneous arterial arrangement resembling that of rabbits. One typical characteristic is the existence of an axial tract alongside the spinal column, which is considered to be closely related to the mobility of the skin. This unique vasculature in the dorsum is one of the advantages to using *S. murinus* as an experimental model in studies focusing on the skin.

Acknowledgments

We thank Dr. Atsushi Yamanaka for providing the animals and Mr. Kazuto Fukushige for assistance in preparing the specimens. This work was supported by a KAKENHI Grant from the Japan Society for the Promotion of Science (Number 23650238).

References

1) Oda S, Kondo K. Progress in domestication of *Suncus murinus riukiuanus* for experiment. Mammal Sci Jpn 1976; 33: 13-30 (in Japanese)
2) Oda S, Kondo K. Usefulness of wild insectivores as laboratory animals. Exp Anim 1977; 26: 273-280 (in Japanese)
3) Tsuji K, Ishikawa T. Some observations of the caravanning behavior in the musk shrew (Suncus murinus). Behavior 1984; 90: 167-183
4) Isomura G. Blood supply to the cranial venae cavae and the heart in the laboratory shrew (*Suncus murinus*). J Anat 1993; 183: 537-543
5) Bedford JM, Mori T, Oda S. Ovulation induction and gamete transport in the female tract of the musk shrew, Suncus murinus. J Reprod Fert 1997; 110: 115-125
6) Yi S-Q, Shimokawa T, Akita K, Ohta t, Kayahara M, Miwa K, Tanaka S. Anatomical study of the pancreas in the house musk shrew (*Suncus murinus*), with special reference to the blood supply and innervation. Anat Rec Pt A 2003; 273A: 630-635
7) Temple JL. The musk shrew (Suncus murinus): A model species for studies of nutritional regulation of reproduction. ILAR J 2004; 45: 25-34
8) Yamanaka A, Yasui K, Sonomura T, Uemura M. Development of heterodont dentition in house shrew (Suncus murinus). Eur J Oral Sci 2007; 115: 433-440.
9) Sharma DR. Studies on the anatomy of the Indian insectivore, Suncus murinus. J Morphol 1958; 102: 427-553
10) Isomura G. Muscular system. In: Oda S, Kitho J, Ota K, et al. editors. Suncus murinus, Biology of the Laboratory Shrew. Tokyo: Japan Scientific Societies Press; 1985: l99-209 (in Japanese)
11) Machado MJC, Watson MG, Devlin AH, Chaplain MAJ, McDougall SR, Mitchell CA. Dynamics of angiogenesis during wound healing: Acoupled in vivo and in Silico study. Microcircul 2011; 18: 183-197
12) Boulaftali Y, Lamrani L, Rouzaud MC, Loyau S, Jandrot-Perrus M, Bouton MC, Ho-Tin-Neo B. The mouse dorsal skinfold chamber as a model for the study of thrombolysis by intravital microscopy. Thromb Haemost 2012; 107: 962-971
13) Hillel AT, Nahas Z, Unterman S, Reid B, Axelman J, Sutton D, Matheson C, Petsche J, Elisseeff JH. Validation of a small animal model for soft tissue filler characterization. Dermatol Surg 2012; 38: 471-478
14) Japanese Society of Veterinary Science (Ed). Nomina Anatomica Veterinaria Japonica. 3rd ed. Tokyo, Gakuso-sha; 2000
15) Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: experimental study and clinical applications. Br J Plast surg 1987; 49: 113-141
16) Taylor GI, Minabe T. The angiosomes of the mammals and other vertebrates. Plast Reconst Surg 1992; 89: 181-215
17) Taylor GI. The blood supply of the skin. IN: Thorne CH, Bartlett SP, Beasley RW, et al. editor; Grabb and Smith's Plastic Surgery. 6th ed, Philadelphia; Lippincott Williams and Wilkins, 2007: 33-41