Morphometrical Changes of the Arterial Walls of Main Arteries from Heart to the Abdomino-Inguinal Mammary Glands of Rat from Virgin through Pregnancy, Lactation and Post-Weaning

AWAL Mohammad Abdul, Mitsuharu MATSUMOTO, and Hayao NISHINAKAGAWA

Department of Veterinary Anatomy, Faculty of Agriculture, Kagoshima University, Kagoshima 890, Japan

(Received 3 August 1994/Accepted 12 December 1994)

ABSTRACT. Morphometrical changes of the arterial walls from the ascending aorta to the abdomino-inguinal mammary glands of rat from virgin through pregnancy, lactation and post-weaning stages were investigated by using a light microscope and an image analyzer. Based on the histological architecture and organization of connective tissue fibers and smooth muscle cells in the media, the arterial segments were clearly identified into three types; elastic, transitional and muscular types. The ascending aorta, the aortic arch, the thoracic aorta and the abdominal aorta were identified as elastic type and the maximum number of elastic lamellae was recorded in the ascending aorta as 10-13. In elastic type of arteries, the tunica media was thicker than other tunics with the exception of the abdominal aorta, in which the tunica externa was a little bit thicker than that of the media. From the external iliac artery to the proximal part of the femoral artery, the arterial segments were transitional in type and the elastic lamellae were ranged from 1-3 in numbers. The deep circumflex iliac, the external pudendal, the caudal superficial epigastric, and the mammary arteries were identified as muscular type, and the media was completely devoid of elastic lamellae. Distinguishable significant changes of diameters and thickness of the arteries were recorded in the deep circumflex iliac, the external pudendal, the caudal superficial epigastric and the mammary arteries, and showed that the diameters and thickness were gradually increased during pregnancy and reached to the maximum values during lactation and again decreased following the post-weaning stages. It is assumed that the histological arrangements of tissues in the arterial walls and the changes of diameters and thickness among the reproductive stages are certainly closely related to the functional demand of the mammary glands.—KEY WORDS: classification of artery, mammary gland, morphometry, rat, reproductive cycle.


It is well known that mammary buds differentiate and proliferate during pregnancy and lactation, and that the vasculature develops maximally during lactation in mice [7, 9, 11, 13, 16] and rats [8, 10, 11, 12]. The changes of density and architecture of microvessels of the rat and mouse mammary glands during pregnancy and lactation were also studied [9, 17]. Concerning the histological study on the arterial walls, it has been reported in the dog [4] and miniature swine [15]. Basically no such reports are available in the literatures concerning the histological architectures and morphometrical changes of the arteries in relation with the various phases of the development of mammary glands in rats.

Therefore, the present study was undertaken to clarify the general histological features of the arterial walls and the changes of diameters and thickness of the vessels specially related for supplying blood to the abdominolingual mammary glands of rat from virgin through pregnancy, lactation, and post-weaning stages.

MATERIALS AND METHODS

A total of 24 Wistar female rats in stages of virgin (90 day-old), pregnancy (15 days), lactation (10 days), and post-weaning (10 days after weaning) were used in this study. Each stage group consisted of 6 animals. The animals were given a commercial diet and water ad libitum. During lactation, each mother rat was housed with 10-13 pups. The animals were anesthetized with Nembutal (R) 50 μg/g body weight by intraperitoneal injection and subsequently sacrificed by exsanguination following incision of the left common carotid artery. Twelve arterial segments were carefully dissected out (Fig. 1) and immediately fixed in 10% buffered neutral formalin. All the tissues were routinely embedded in paraffin wax and sectioned at 6 μm. Four stains were used during the study as Mayer's hematoxylin and eosin, Weigert's resorcin fuchsin, Weigert's elastica Van Gieson, and Azan stain. All the tissues were observed with a light microscope and the outer and inner diameters and

thickness of the arterial wall were measured with an image analyzer (Nikon Cosmozone IS). The data were statistically analyzed by Student’s t test.

RESULTS

Morphological features: The arterial segments were classified as elastic, transitional and muscular type on the basis of histological features and deposition of elastic fibers, collagen fibers and smooth muscle cells in three distinct coats; tunica intima, tunica media and tunica externa. From the ascending aorta to the abdominal aorta, the segments were identified as elastic type (Fig. 1). Among those elastic arteries, the number of elastic lamellae in the tunica media were recorded in the ascending aorta as 10–13 (Fig. 2a), the aortic arch as 8–10, the thoracic aorta as 7–8 (Fig. 2b) and the abdominal aorta as 5–6 (Fig. 2c) respectively. The tunica media was observed thicker than the tunica externa in large arteries. The tunica externa was comparatively thinner than the media and consisted of mixtures of collagen fibers, smooth muscle cells and a little degree of elastic fibers. The tunica intima consisted of a single layer of flattened endothelium resting on the innermost elastic lamella. The subendothelial layer was clearly observed in the ascending aorta, the aortic arch and the thoracic aorta. In the abdominal aorta, the tunica externa was thicker than the tunica media. The elastic lamellae in the media were comparatively thinner and irregular in nature with sharply broader interlaminal spaces (Fig. 2c). The tunica externa was composed of mainly collagen fibers and a small amount of elastic fibers.

![Fig. 2. (a) Ascending aorta, showing the well developed tunica media consisting of maximum number of elastic laminae. Virgin stage. Weigert’s resorcin fuchsin. × 600. (b) Thoracic aorta, showing thick elastic lamellae in the media and the relatively thin tunica externa. Virgin stage. Elastica Van Gieson. × 600. (c) Abdominal aorta. The elastic laminae are thin, interlaminal spaces become broader, the tunica externa is a little bit thicker than the tunica media. Virgin stage. Weigert’s resorcin fuchsin. × 600. (d) External iliac artery. Both external and internal elastic laminae are present. The media consists of minimum number of elastic laminae with well developed tunica externa. Virgin stage. Elastica Van Gieson. × 600.](image-url)
Collagen fibers from the innermost layer of the tunica externa entered into the outermost layer of the tunica media and interrupted the continuity of smooth muscle cells.

From the external iliac artery to the proximal part of the femoral artery, the segments were transitional in type and the elastic lamellae were ranged from 1-3 in numbers (Fig. 2d). Both the external and internal elastic laminae were present. The tunica externa was thicker than the tunica media. The media consisted of irregular elastic lamellae along with thick elastic fibers and smooth muscle cells.

The deep circumflex iliac, the pudendoepigastric trunk, the external pudendal, the caudal superficial epigastric, the distal part of the femoral and the mammary arteries were belonged to the muscular type having the numerous smooth muscle cells in the media (Fig. 1). In the muscular arteries, the tunica externa was dominantly well developed. Both the external and internal elastic laminae were observed prominent. Although the media completely devoided of elastic lamellae, some thick elastic fibers were observed in the media of the deep circumflex iliac artery and the pudendoepigastric trunk (Fig. 3a). The weavy nature of the internal elastic lamina was prominent-ly observed in the deep circumflex iliac, the external pudendal, the caudal superficial epigastric and the mammary arteries in virgin stage (Fig. 3a-c), that gradually lost their weavy characters following pregnancy to the lactation period (Fig. 3d). No other different features were observed among the stages under the light microscope.

Morphometrical changes: Although there were no significant differences in the ascending aorta, the aortic arch, the thoracic aorta and the abdominal aorta in each stage (Fig. 4), apparently considerable changes were observed in the external iliac artery, the pudendoepigastric trunk, and the proximal part of the femoral artery (Fig. 5). Comparatively very low pattern of changes were shown in the distal part of the femoral artery (Fig. 5).

In our observation, clearly distinguished changes of diameters and thickness were recorded in muscular type of arteries, particularly in the deep circumflex iliac, the caudal superficial epigastric and the external pudendal arteries (Fig. 6), which were designed for supplying blood to the abdmino-inguinal mammary glands. The changes of each artery were significantly different from one stage

Fig. 3. a) Deep circumflex iliac artery, muscular type of artery. The media consists of thick elastic fibers. Note well defined internal elastic lamina with weavy character. Virgin stage. Elastica Van Gieson. × 500. b) External pudendal artery. The media of the wall consists of fine elastic fibers with weavy internal elastic lamina. Virgin stage. Weigert’s resorcin fuchsin. × 500. c) Caudal superficial epigastric artery. Both external and internal elastic laminae are prominent. The well developed tunica externa consists of abundant collagen fibers, while the media composes of numerous smooth muscle cells with a small amount of fine elastic fibers. The internal elastic lamina with weavy character. Virgin stage. Elastica Van Gieson. × 500. d) Caudal superficial epigastric artery. The internal elastic lamina is straight in lactation. Lactation stage. Elastica Van Gieson. × 500.
to another. In the caudal superficial epigastric artery, the outer diameters and thickness (μm) increased during pregnant period (357.30±6.25; 57.19±3.03) and reached to the maximum values in lactating stage (400.31±16.41; 75.49±7.03), which gradually decreased following post-weaning (370.08±9.52; 63.11±4.84). The similar pattern of measurements was revealed by the deep circumflex iliac and external pudendal artery, respectively (Fig. 6).

**DISCUSSION**

The classification of arteries was based on the relative volume and deposition of connective tissue fibers in three distinct coats; tunica intima, tunica media, and tunica externa, which are obviously related to the physiological demand of the volume of blood to suit the needs of the region irrigated. As described by Arthur [2], Bloom and Fawcett [3], and Bunce [4], the arterial segments in this study were also classified as 3 types; elastic, transitional and muscular types.

From the ascending aorta to the abdominal aorta, the large arterial segments were classified as elastic type, although Tanigawa et al. [15] described the abdominal aorta as transitional type in miniature swine. The histological features of the abdominal aorta also showed a little bit different from other elastic arteries. The tunica media was thinner than the tunica externa, and the elastic lamellae were thin and irregular in nature and the interlaminal spaces were broader. The elastic fibers forming circular arrangements around the tunica media and specially in the innermost side of the tunica externa were reported in transitional and muscular types of arteries in miniature swine [15] and dog [1, 4], but these features were not observed in the present study. Usually the small arteries, the peripheral branches of arterial tree, were identified as muscular type. Both internal and external elastic laminae were present in the muscular type of arteries. The media consisted of circularly arranged smooth muscle cells with a few very fine elastic fibers [6, 15]. However, in the media of the deep circumflex iliac artery and the pudendoepigastric trunk, some comparatively thick elastic fibers were observed. Arthur [2] described that the media of the muscular arteries in man was a fairly thick coat consisted of chiefly circularly disposed smooth muscle cells, and was held
MORPHOMETRICAL CHANGES OF RAT ARTERIES

The vessels supplying the mouse mammary glands increased rapidly in size with advancing of pregnancy and during the period of lactation. Matsumoto et al. [9] and Yasugi et al. [17] described that the pregnancy and lactation affect the microvasculature of the mouse and rat mammary glands. In our experiment, the deep circumflex iliac and the caudal superficial epigastric arteries showed the maximum values of diameters and thickness in lactating period. Moderate changes of diameters and thickness were observed in the external iliac artery, the proximal part of the femoral artery and the pudendoepigastric trunk, although very negligible changes were observed in the distal part of the femoral artery which convey blood to the leg only. Forbes and Taku [5] pointed out that the femoral vein increased in diameters during lactation, presumably to accommodate the greater venous drainage from the functional demand of the mammary glands. On the other hand, the changes in the ascending aorta, the aortic arch, the thoracic aorta and the abdominal aorta showed no significant differences among the reproductive cycles.

In conclusion, it can be stated here that the changes of the blood vessels supplying the abdovino-inguinal mammary glands exclusively depend upon the functional demand of the mammary glands and the fact is consonant with the well known increase in blood supply during pregnancy and lactation related to the growing metabolic requirements of mammary tissues for milk production. Regression of the vessels following post-weaning stage is assumed due to decrease flow of blood through the arteries as apparently less amount of blood utilized by the involuted mammary glands.

ACKNOWLEDGEMENTS. The authors are grateful to the Department of Veterinary Pharmacology, Kagoshima University, for supplying the experimental animals, and also like to extend heartfelt gratitude to Dr. K. Mamba, Associate Professor, Department of Veterinary Anatomy, Yamaguchi University, for his continuous inspiration and suggestion during the experiment and making the manuscript.

REFERENCES