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# HISTOLOGICAL STUDIES ON THE OVARIES OF SOWS III. ON THE ELASTIC FIBERS OF THE WALL OF BLOOD VESSELS IN VARIOUS HISTOLOGICAL STRUCTURES

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## INTRODUCTION

Normal ovarian follicles, atretic follicles and corpora lutea throughout the developmental and regressive processes are considered to suffer conspicuous changes ranked next to those, which are given rise to with gestation and parturition, of uteri or mammary glands. These considerable changes should be expected to relate to the behaviors of the blood vessels distributed in the various structures of the ovaries. So the histopathological changes in the blood vessels, especially in arterioles, become a subject of discussion.

Histological investigations on the blood vessels of human ovaries have been reported by WOLTKE (1900), GRUBE (1902), BÖSHAGEN (1904), PANKOW (1906), SOHMA (1908), ISONO (1932) and TSUJIMURA (1936). However, they described only the existence and histogenesis of specific sclerotic changes, the so-called "ovulation sclerosis" and "senile sclerosis", occurring in the small blood vessels of the theca externa in mature follicles, of the periphery of corpus albicans and of stroma ovarii. ONO was the first to find the "elastolipoidosis" advocated by him in the connective tissue of a fibrous center of corpus albicans. And he mentioned that this may belong to the same category of morphology as the so-called "ovulation sclerosis."

In cows, monkeys and hens TSUJIMURA (1936) recognized the changes which correspond with "ovulation sclerosis" of women. DUKE (1945, 1947) mainly observed the arterioles found in the ovarian stroma of dogs and rabbits.

In the cases of sows, on the other hand, CLARK (1900), CORNER (1919) and ANDERSON (1926) have respectively reported results obtained by the use of vascular injection methods.

The present writer and his co-workers<sup>21)</sup> have previously reported about the changes of the uterine arteries (A. uterina media) of the sow. Even in such an artery of moderate size the elastic tissue of the wall was recognized to change greatly, although other constituents except interstitial substance appeared to remain almost the same.

In this paper the changes in the elastic tissue of small blood vessels found in the structures of 6 groups based on hematoxylin-eosin (H.-E.) preparations are described.

#### MATERIALS AND METHODS

Materials for this research are pairs of ovaries of 34 sows used in the present writer's second report and chiefly right ovaries of 17 other sows collected newly. (In left ovaries of the new 17 sows neoprene-latex was injected into their ovarian artery respectively for the purpose of making neoprene-latex cast specimens of arterioles in ovaries).

As a routine matter, the specimens were fixed with 10% formalin and sectioned, and then treated with hematoxylin-eosin stain and WEIGERT's stain for elastic fibers.

Findings of WEIGERT stain preparations were compared with the findings of H.-E. preparations. The number of objects belonging respectively to the 6 groups of histological structures of H.-E. preparations are indicated in table 1.

TABLE 1. *Total Numbers of Six Groups of Structures on the Basis of H.-E. Preparations*

STRUCTURES	NUMBER OF TYPE	TOTAL
Normal vesicular follicles	6	127
Cystic atretic follicles	12	227
Atretic follicles with hemorrhage	4	7
Corpora lutea of non-pregnancy without a large central cavity	10	150
Corpora lutea of non-pregnancy with a large central cavity	6	14
Vascular bodies	3	19

#### FINDINGS

##### I. Classification of Arterioles found in Various Structures of Ovaries

The arterioles found in the various structures of 6 groups in H.-E. preparations were divided into 14 types according to the existence of arteriosclerotic changes, as shown in table 2.

Type 1: The arterioles of this type are about 10 to 40  $\mu$  in diameter. In cross section the internal elastic membrane just beneath the endothelial cells appears as a very fine granular line. Elastic fibers are not found in the intermediate coat, which consists of one or two layers of smooth muscle cells arranged concentrically.

Type 2: The arterioles are about 30 to 80  $\mu$  in diameter. In cross section there is found homogeneously deep-stained, thin internal elastic membrane directly beneath the endothelial cells. Neither the intermediate coat which consists of 2 to 3 cell layers of smooth muscle cells nor the outer coat which consists of loose connective tissue contains elastic fibers.

Type 3: The arterioles are about 70 to 110  $\mu$  in diameter. The structure of the internal elastic membrane is similar to that of arterioles of type 2. In the intermediate coat some

TABLE 2. *Typing of Arterioles*

Elastosis in the intermediate coat	-													+
Hyaline swelling in the intermediate coat	-						+						-	
Hyperplastic swelling of the inner coat	-			+			-			+			+	
Smooth muscle cells of the intermediate coat	+			+			-	+		-	+	+	+	
Thickening of the internal elastic membrane	-			+			-	+	-	-	+	-	-	+
Quantity of elastic fibers in the intermediate coat	-	+	+	++	+	++	+	+	-	+	+	-	+	++
Type of arterioles	1	2	3	4	5	6	7	8	9	10	11	12	13	14

fine elastic fibers are found between the smooth muscle cells.

Type 4: The arterioles are about 100 to 130  $\mu$  in diameter. The internal elastic membrane also shows a structure similar to that of arterioles of type 2. A few fine elastic fibers and even some slightly swollen ones appear between the smooth muscle cells of the intermediate coat. In the outer coat there are a few fine elastic fibers.

Type 5: The arterioles are about 70 to 110  $\mu$  in diameter. In cross section the internal elastic membrane swells more than that of the arterioles of type 3, and appears as homogeneous thick ring with small folds.

Type 6: The diameter of the arterioles is like that of type 5. The internal elastic membrane is markedly thick like that of type 5. In the intermediate coat a few thin elastic fibers are found between the smooth muscle cells as in the arterioles of type 4.

Type 7: The diameter of the arterioles is the same as that of type 3. In this type there is found hyperplasia of the inner coat; namely, some quantity of connective tissue is distinctly observed between the endothelial cells and the thin internal elastic membrane. No elastic fiber was detected in such a thickened subendothelial tissue. In the intermediate coat a few elastic fibers appear like arterioles of type 3.

Type 8: The diameter of the arterioles is about 40 to 200  $\mu$ . The hyperplastic swelling of the inner coat is more conspicuous than that of type 7, and there are very minute elastic fibers in the thickened subendothelial tissue. Moreover the thickening of the internal elastic membrane is conspicuous. The features of the intermediate coat are similar to those of type 6.

Type 9: The arterioles are about 40 to 60  $\mu$  in diameter. Two or three endothelial cells surround the innermost layer of the narrow cavity. The internal elastic membrane beneath the endothelial cells appears as a blue stained, very fine line. The intermediate coat and the outer coat are found as a band of homogeneous hyaline substances. In such part there are found a few, pale, minute fibers and some degenerated smooth muscle cells or fibrocytes.

Type 10: The arterioles are about 50 to 70  $\mu$  in diameter. The pale blue, fine internal

elastic membrane is observed beneath the endothelial cells surrounding the narrow cavity. The one or two cell layers of the smooth muscle cells of the intermediate coat remain adjacent to the internal elastic membrane. Between these smooth muscle cells there are seen some pale elastic fibers. The outer side of the intermediate coat is surrounded with a homogeneous band of hyaline substances.

Type 11: The diameter of the arterioles is like that of type 10. The intermediate coat of this type resembles that of type 10, but the internal elastic membrane is thicker and deeper stained than that of type 10.

Type 12: The diameter of the arterioles is almost the same as that of type 10. Between the endothelial cells surrounding the narrow cavity and the slightly thickened internal elastic membrane there is found a distinct thin homogeneous layer, in which no cellular elements or one or two pycnotic nuclei and some debris are seen. The intermediate coat is similar to that of type 9.

Type 13: The arterioles are about 70 to 100  $\mu$  in diameter. Beneath the endothelium a thin homogeneous layer is found like that of type 12, but in this type a few, various degenerated nuclei are usually seen in this layer. The intermediate coat resembles that of type 10.

Type 14: The diameter of the arterioles is about 50 to 200  $\mu$ . In this type the hyperplastic swelling of the inner coat is remarkably conspicuous. The internal elastic membrane breaks and splits at some portions. In the intermediate coat, thin fibers and thick ones mingle and are packed closely into remarkable thick fibers. Moreover masses of homogeneous substances, which stain deeply and dirtily, scatter throughout the intermediate coat and the outer coat.

## II. Findings on Normal Vesicular Follicles (EF.)

In this research, normal vesicular follicles could not be classified in subgroups from the findings on arterioles found in the walls of follicles, although these follicles have been divided into 6 types according to the observations in H.-E. preparations.

To sum up, in all follicles of this group (EF.) the theca interna contains only networks of capillaries, while only arterioles of types 1 and 2 were seen in the theca externa.

## III. Findings on Cystic Atretic Follicles (Eaf.)

Showing no difference in the findings of the arterioles appearing in the follicle wall, the two groups of cystic atretic follicles and of atretic follicles with hemorrhage were placed in one group and divided into 3 types, as shown in table 3.

TABLE 3. *Typing of Atretic Follicles*

PORTION	TYPE OF ARTERIOLES	TYPE		
		Eaf. I	Eaf. II	Eaf. III
Theca interna	1, 2	—	+	
Theca externa	1	+	+	
Hyaline layer	9, 10			+
Radial layer	1, 2			+

Type Eaf. I: The appearance of arterioles in the follicle wall of this type resembled that of normal vesicular follicles.

Type Eaf. II: Arterioles of type 1 appeared newly in the theca interna. In the theca externa only arterioles of types 1 and 2 appeared as in type Eaf. I. In the more advanced atretic follicles, in which the demarcation between the theca interna and the theca externa was obscure in H.-E. preparation, arterioles of type 1 were observed at the inner side of the follicle wall, while those of types 1 and 2 were found at the outer side.

Type Eaf. III: In this type, showing scar-tissues in H.-E. preparation, there appeared arterioles of type 9 in the inner side of the hyaline layers, and ones of type 10 in the outer side. In the radial layer arterioles of types 1 and 2 were found.

The relations between the typing based on H.-E. preparations and the typing based on WEIGERT preparations of atretic follicles are set out in table 4.

TABLE 4. *Relation between Typing Based on H.-E. and on WEIGERT Preparations of Atretic Follicles*

H.-E. PREPARATION		WEIGERT PREPARATION			TOTAL
		Eaf. I	Eaf. II.	Eaf. III	
	AF. I	26			26
	" II	11			11
	" III	32	33		65
	" IV		13		13
	" V		26		26
Cystic atretic follicles	" VI		14		14
	" VII		17		17
	" VIII		4		4
	" IX		3		3
	" X			24	24
	" XI			18	18
	" XII			6	6
	aF. I	1			1
Atretic follicles with hemorrhage	" II		2		2
	" III		3		3
	" IV			1	1
Total		70	115	49	234

In cystic atretic follicles, all follicles at the early stages of atresia (types AF. I and II) and about a half of follicles at the more advanced stage (type AF. III) showed findings similar to those of normal vesicular follicles. At the middle stages of atresia (types AF. IV to IX) arterioles of type 1 were observed to proliferate actively from the theca externa into the theca interna for the first time; at the last stages (types AF. X to XII) arterioles themselves came

to undergo the hyaline swelling in their wall with the hyalinization of the interstitial tissue in the hyaline layers.

In atretic follicles with hemorrhage the details of the appearance of arterioles in the follicle wall were considered to be similar to those of atretic follicles of the previous group.

#### IV. Findings on Corpora Lutea of Non-pregnancy (EL).

Showing no difference in the findings on arterioles, the two groups of corpora lutea of non-pregnancy and of those with a large central cavity were put together and divided into 6 types, as shown in table 5.

TABLE 5. *Typing of Corpora Lutea of Non-pregnancy*

LUTEIN CELL LAYER	TYPE OF ARTERIOLES	TYPE					
		EL. I	EL. II	EL. III	EL. IV	EL. V	EL. VI
Peripheral layer	1	+	+	+	+	-	-
	2	-	-	+	+	-	-
	3	-	-	-	+	-	-
	4	-	-	-	+	-	-
	7	-	-	-	+	-	-
	9	-	-	-	+	+	+
	10	-	-	-	-	+	-
	12	-	-	-	-	+	+
Deeper layer	13	-	-	-	-	+	+
	1	-	+	+	+	-	-
	2	-	-	-	+	-	-
	7	-	-	-	+	-	-
	9	-	-	-	+	+	+
	10	-	-	-	-	+	-
	12	-	-	-	-	-	+
13	-	-	-	-	-	+	

Type EL. I: In this type there appeared only arterioles of type 1 just beneath the capsule.

Type EL. II: In this type arterioles of type 1 were seen to proliferate from the peripheral layer of the lutein cell layer into the deeper layers.

Type EL. III: There newly appeared arterioles of type 2 in addition to ones of type 1 in the peripheral layer of the lutein cell layer. But in the deeper layers, only arterioles of type 1 were seen.

Type EL. IV: In this type there newly appeared larger arterioles of type 7 and small ones of type 9 throughout the lutein cell layer. Relatively large arterioles found under the capsule have altered into either type 3 or type 4.

Type EL. V: In this type, arterioles of types 1 and 2 have disappeared from all parts

of the lutein cell layer. There have also disappeared all arterioles of types 3, 4 and 7 in the deeper layers. On the contrary, arterioles of type 9 have somewhat increased throughout the whole wall. Moreover in this type 9 there appeared newly arterioles of types 10, 12 and 13 in the peripheral layer and ones of type 10 in the deeper layers.

Type EL. VI: Corpora lutea of this type were similar to those of type EL. V. But in this type there appeared newly arterioles of types 12 and 13 in the deeper layers and arterioles of type 10 disappeared entirely from the whole wall unlike type EL. V.

The relations between the typing based on H.-E. preparations and the typing based on WEIGERT preparations of corpora lutea of non-pregnancy and ones with a large central cavity are set out in table 6.

TABLE 6. *Relation between Typing Based on H.-E. and on WEIGERT Preparations of Corpora Lutea of Non-pregnancy*

H.-E. PREPARATION	WEIGERT PREPARATION						TOTAL
	EL. I	EL. II	EL. III	EL. IV	EL. V	EL. VI	
CL. I	6						6
" II	11						11
" III		10					10
Without a large central cavity		16					16
" IV		16					16
" V		16					16
" VI			4				4
" VII			16				16
" VIII				25			25
" IX					17		17
" X						29	29
Cl. I	2						2
" II	2						2
With a large central cavity		6					6
" III		6					6
" IV		1					1
" V			1				1
" VI				2			2
Total	21	49	21	27	17	29	164

In corpora lutea of non-pregnancy at the earlier vascularization stages (CL. I and II) only arterioles with a fine internal elastic membrane (type 1) are found beneath the capsule. At the more advanced vascularization stage (CL. III), the bloom stage (CL. IV) and the earliest stage of regression (CL. V), arterioles with a fine internal elastic membrane are observed to proliferate as far as the deeper layers of the lutein cell layer. At the early stage of regression (CL. VI) and the middle stage (CL. VII) some arterioles found in the peripheral layer of the lutein cell layer begin to have the distinct internal elastic membrane (type 2). At the more

advanced stage (CL. VIII) relatively large arterioles found under the capsule come to show increase of elastic fibers in the intermediate coat (types 3 and 4). In large arterioles the whole wall shows the hyperplastic swelling of the inner coat (type 7), and in small arterioles shows the hyaline swelling of the intermediate coat (type 9). At the last stages (CL. IX and X) majority of arterioles which still remain in the lutein cell layer show various degrees of the hyaline swelling of the intermediate coat simultaneously (types 12 and 13).

In corpora lutea with a large central cavity, arterioles found in the lutein cell layer also have a tendency to show the development and the sclerotic changes similar to those of the corpora lutea of the previous group.

### V. Findings on Vascular Bodies (Eg.)

Vascular bodies were divided into 3 types, as shown in table 7.

TABLE 7. *Typing of Vascular Bodies*

VASCULAR BODIES	TYPE OF ARTERIOLES	TYPE		
		Eg. I	Eg. II	Eg. III
Peripheral portion	2	+	--	--
	3	+	--	--
	5	+	+	--
	6	+	+	--
	8	+	+	+
	9	+	+	+
	10	+	+	+
	11	--	+	+
Central portion	14	--	--	+
	2	+	--	--
	5	+	+	--
	6	+	+	--
	8	+	+	+
	9	+	+	+
	10	+	+	+
	11	--	+	+

Type Eg. I: In the vascular bodies of this type there appeared many arterioles of types 5, 6, 8 and 10 everywhere in the walls of these vascular bodies in addition to ones of types 2, 3 and 9 found in corpora lutea of non-pregnancy at the last stage of regression.

Type Eg. II: Although there disappeared each arteriole as those of types 2 and 3 observed in the previous type, there appeared newly arterioles of type 11 throughout the whole wall of these vascular bodies.

Type Eg. III: In this type the whole wall was occupied by arterioles of type 8. Among

them a few arterioles of types 9, 10 and 11 were observed. Moreover large arterioles of type 14 appeared in the periphery of these vascular bodies.

The relations between the typing based on H.-E. preparations and the typing based on WEIGERT preparations of vascular bodies are set out in table 8.

TABLE 8. *Relation between Typing Based on H.-E. and on WEIGERT Preparations of Vascular Bodies*

H.-E. PREPARATION	WEIGERT PREPARATION			TOTAL
	Eg. I	Eg. II	Eg. III	
g. I	5			5
" II		8		8
" III			6	6
Total	5	8	6	19

Of many arterioles found in vascular bodies, in which a majority of the lutein cells degenerated and the interstitial tissues underwent slight hyaline changes in H.-E. preparations (g. I), small arterioles have already shown hyaline swelling in the intermediate coat (types 9 and 10) and other comparatively large arterioles have shown the thickening of the internal elastic membrane (types 5 and 6) even with the swelling of the inner coat (type 8). At the advanced stage, at which normal lutein cells have disappeared entirely, and the great parts of vascular bodies were occupied by hyaline substances in H.-E. preparation (g. II), in the comparatively larger arterioles, the intermediate coat itself showed the hyaline swelling (types 9 and 10) even with the thickening of the internal elastic membrane (type 11). Many other arterioles were of type 8; they were scattered in the hyaline substances. At a more advanced stage, at which the whole wall of vascular bodies was occupied by arterioles, the majority of these arterioles showed the thickening of the internal elastic membrane and the swelling of the inner coat (type 8).

#### DISCUSSION

Various arterioles which were found in the 6 groups of histological structures of pig ovaries were observed by the use of WEIGERT'S staining and divided into 14 types.

IMAGAWA reported that, in arterioles less than  $20\mu$  in diameter, the internal elastic membrane which is composed of elastic fibers arranged collaterally to the length of the vessel and showing decrease of the branching fibers in proportion to the diameter, showed granular appearance in the cross section.

The present writer's arterioles of type 1 were similar to the arterioles of IMAGAWA, less than  $20\mu$  in diameter, and were observed in the portions showing active proliferation of tissues; i. e. in the wall of ovarian follicles in the processes

of maturing and in the wall of the corpora lutea at the vascularization stage. Therefore these are considered to be newly developed arterioles.

The present writer's arterioles of type 2 resemble well the normal arterioles described by MAXIMOW and BLOOM: the inner coat consists only of endothelium and the internal elastic membrane appears as a thin line just beneath the endothelial cells. The intermediate coat consists of smooth muscle cells arranged in two to several cell layers. In this coat there are observed no elastic fibers.

Hitherto the following arteriosclerotic changes in small arteries have been described: the increasing of elastic fibers in the intermediate coat, the thickening of the internal elastic membrane, the swelling of the inner coat, the elastosis in the intermediate coat and so on.

In this study small arterioles, about 30 to 70  $\mu$  in diameter, were seen containing a few or many minute elastic fibers in the intermediate coat (types 3 and 4). It has been stated that normal small arterioles usually contain no elastic fibers in the intermediate coat. It is especially interesting that the present writer's arterioles of type 4 are closely similar to the arterioles of "type 3" ("an increasing of minute elastic fibers") found in the mucous membrane of corpora uteri of women by SAITO. Accordingly the writer's arterioles of types 3 and 4 are considered as being arteriosclerotic with increase of elastic fibers in the intermediate coat.

In the blood vessels of "type 2" ("thickened internal elastic membrane") of SAITO who observed on the mucous membrane of corpora uteri of women, the internal elastic membrane was thick and dense deep in color, although the calibers of the blood vessels were small. The present writer's arterioles of types 5 and 6 found in the various structures of pig ovaries showed not only thickening of the internal elastic membrane but also increase of elastic fibers in the intermediate coat. Therefore the arterioles of types 5 and 6 are considered to show higher arteriosclerotic changes in comparison with arterioles of types 3 and 4.

MATSUOKA stated that the sclerotic change observed in small and medium-sized arterioles was a hyperplastic swelling of the inner coat with hyperplastic minute elastic fibers, but that the regressive changes were relatively rather less.

The present writer's arterioles of types 7 and 8 showed swelling of the inner coat distinctly. However a small quantity of hyperplastic elastic fibers is found only in the swollen inner coat of type 8. But the intermediate coat of types 7 and 8 contains the same quantity of elastic fibers as those of type 3 or 5 do. Further in type 8 there is found thickening of the internal elastic membrane. Although it differs from MATSUOKA's description, in these arterioles, the increasing of the elastic fibers is always found in the swollen inner coat, therefore these arterioles are considered to be ones with relatively conspicuous changes such as

the thickening of the internal elastic membrane and the increasing of elastic fibers in the intermediate coat.

The present writer's arterioles of type 9 found in "hyaline bodies" are similar to those with "hyaline swelling" in the intermediate coat designated by MATSUOKA, who found a kind of senile arteriosclerosis in arterioles, less than 50  $\mu$  in diameter, of the kidneys, spleen, pancreas and testes.

In type 10 the smooth muscle cells and elastic fibers still remain in the inner side of the intermediate coat. Accordingly arterioles of this type are recognized to be a transitional form into type 9.

Arterioles of type 11 are considered to be ones with the hyaline swelling of the outer side of the intermediate coat and with the thickening of the internal elastic membrane.

Arterioles of types 12 and 13 are recognized to be ones with the hyaline swelling and with the swollen inner coat.

Up to this time the arteriosclerotic change which is the so-called "ovulation sclerosis" in arterioles found in ovaries of women and other animals has been well known; the variously formed and sized masses of dirty black purple homogeneous substances, "elastoid tissues," accumulate in the intermediate coat and the outer coat.

The present writer's arterioles of type 14 may belong to the same category as the just noted arteriosclerosis.

Normal vesicular follicles could not be differentiated in this research.

It has been stated by WOLTKE, BÖSHAGEN, PANKOW, ISONO and TSUJIMURA in women that the so-called "ovulation sclerosis" is found in small arteries of the theca externa of ovarian follicles, especially of mature follicles. SOHMA reported in women that in the arterioles of mature follicles there was found an increasing of elastic fibers in the intermediate coat, but there was no appearance of elastoid tissues. In cows, monkeys and hens TSUJIMURA recognized the same changes as SOHMA did, whilst DUKE could not observe the accumulation of elastic fibers in the wall of mature follicles of dogs and rabbits.

The present writer observed in the cases of sows that, in growing follicles, in mature follicles or even in follicles just before rupture, new arterioles and normal small ones appeared only in the theca externa and no arterioles appeared in the theca interna. Thus the writer's observations differ from every one of the results obtained by above named investigators.

Cystic atretic follicles and atretic ones with hemorrhages were divided respectively into 3 types in this study.

WOLTKE has observed a kind of "senile sclerosis", which is similar to the so-called "gravity sclerosis" found in the arterioles of the uterine muscular layer,

in the arterioles of the wall of human atretic follicles at the last stage. TSUJIMURA recognized a sclerotic change which differed from the so-called "ovulation sclerosis" in the arterioles of the theca externa of atrophied follicles in children: the inner coat swelled slightly, elastic fibers of the intermediate coat thickened and increased, and the intermediate coat showed a conspicuous fatty degeneration.

In the cases of sows, the writer's observations differed completely from the above two results. To sum up, at earlier stage of regressive process new arterioles and normal small ones appear only in the theca externa, and at the more advanced and the middle stage new arterioles begin to penetrate from the theca externa into the theca interna for the first time. At the last stage, however, arterioles themselves undergo "hyaline swelling" with hyalinization of the theca interna, and finally disappear.

On the alteration of blood vessels of corpora lutea with the development and the regressive process, no description may be found, although WOLTKE and many other investigators have reported the appearance of the so-called "ovulation sclerosis" in the small arterioles found in the periphery of corpus albicans.

The present writer observed various arterioles which appeared in the lutein cell layers with the development and the regressive process of corpora lutea of non-pregnancy, and divided these corpora into 6 types according to the conditions of the appearances of these arterioles.

To summarize, in corpora lutea at the vascularization stage new arterioles proliferate actively from the capsule into the lutein cell layer, and at the bloom stage these arterioles reach as far as the deep parts of the lutein cell layer. Such a condition hardly changes from the beginning stage of regression to the middle stage, except that arterioles under the capsule come to have a conspicuous internal elastic membrane. At the beginning of the last stage of regression, however, arterioles showing arteriosclerotic changes suddenly occurred in the lutein cell layer; relatively large arterioles with increase of minute elastic fibers in the intermediate coat are found in the superficial layer of the lutein cell layer, and ones with swollen inner coat and small ones showing hyaline swelling of the intermediate coat are found throughout the lutein cell layer.

In large arteries such as a ductus arteriosus (BOTALLI) and an umbilical artery, the ceasing of their function results in conspicuous swelling of the intermediate coat and final obliteration of the canal cavity (BABA or NISHIMURA). Therefore in smaller arterioles of corpora lutea of non-pregnancy such a cessation is considered to give rise to slight swelling of the inner coat. And in the smallest arterioles of corpora lutea such a cessation can also be surmised naturally to give rise to the disappearance of elastic fibers or hyaline swelling in the intermediate coat.

In hyaline bodies showing heavy hyalinization of the interstitial tissues, a majority of the arterioles come to undergo "hyaline swelling" of the entire wall, and disappear gradually.

It has been reported by many other investigators in women or a few other animals that small arteries with so-called "ovulation sclerosis" are observed in the periphery of the corpus albicans.

In the present writer's cases of sows, arterioles of type 14, which are considered to correspond to the above described "ovulation sclerosis", were always found at the periphery of hyaline bodies. If one observed carefully, however, arterioles of this type may be seen in or near the capsule at all stages of the development and the regressive process of corpora lutea of non-pregnancy; the frequency of their appearance shows no change. Moreover these arterioles were difficult to distinguish from the arterioles of the ovarian stroma. Accordingly the present writer left out consideration of these arterioles from the findings necessary to the typing of corpora lutea of non-pregnancy.

Vascular bodies, which the present writer have thought to represent old corpora lutea of pregnancy of the sow, were divided into 3 types in this study.

With the disappearance of lutein cells and the hyalinization of interstitial tissues, the majority of the small arterioles found in the vascular bodies undergo the hyaline swelling of the intermediate coat. However, many relatively large arterioles come to show increase of minute elastic fibers in the intermediate coat, thickness of the internal elastic membrane and even swelling of the inner coat, remain in hyalinized interstitial tissues, and finally only such arterioles maintain themselves there, although the hyaline substances of the interstitial tissues disappear. Thus a mass of blood vessels, the writer's so-called "vascular bodies" was considered to be formed.

To sum up, it is thought that in vascular bodies the arterioles with more marked dilatation and hyperemia than those of arterioles in the corpora lutea of non-pregnancy had maintained their function for a long time, and had proceeded slowly in the regressive processes, because of the remarked thickening of the internal elastic membrane and the swelling of the inner coat.

On the subsequent fate of the arterioles of vascular bodies, it is surmised that the accumulation of the so-called "elastoid tissues" is accompanied by the degeneration of the elastic tissues in their wall. After the destruction of the arterioles, only the "elastoid tissues" may still remain in the interstitial ground substances for a long while. Such pictures deduced by the writer at the last stage of vascular bodies are considered to resemble well the corpus albicans with the "elastolipoidosis" which recently was reported by ONO in women.

Up to this time, old features of the corpora lutea both of menstruation and

of pregnancy in women have not been distinguished histologically and both have been designated as "corpus albicans."

In cows it is reported by McNUTT and other investigators that old corpora lutea of non-pregnancy remain as "corpus rubrum" for a short time. The present writer unfortunately could not find reports based on the common opinion that old corpora lutea of pregnancy remain as "corpus albicans" perpetually.

According to the present writer's conception that vascular bodies were old corpora lutea of pregnancy in sows, ONO's corpora albicantia, which are associated with the changes of so-called "elastolipoidosis" in the connective tissue of the fibrous center of corpora albicantia, should be considered to be the last features of human corpora lutea of pregnancy.

In the case of the cow, corpora lutea of pregnancy in the regressive process maintain their luteal structures up to the day of delivery. Therefore blood vessels, especially arterioles, found in the structures are expected to be exposed to much more mechanical stress in comparison of the luteal structures of corpora lutea of pregnancy in more short than a half of pregnant period of cows. This is the reason that corpora lutea of cows maintain their scar-like features as lifelong structures, and those of sows as so-called vascular bodies which are demonstrable histologically only.

#### SUMMARY

The results of this research may be summarized as follows.

- 1) Various arterioles found in the 6 groups of the structures of pig ovaries were divided into 14 types.
- 2) In this research all of normal vesicular follicles in the process of the maturation, mature ones and ones just before the rupture showed the same finding: i. e., newly formed arterioles and normal small ones were found only in the theca externa.
- 3) Atretic follicles were divided into 3 types.
- 4) At the early stage of regressive processes the findings of arterioles found in follicle walls are similar to those of normal vesicular follicles. At the middle stage new arterioles protrude actively from the theca externa into the theca interna. And at the last stage, according to the hyalinization of the inner walls of follicles, arterioles themselves in such parts come to undergo the hyaline swelling of the intermediate coat, and finally disappear gradually.
- 5) Corpora lutea of non-pregnancy were divided into 6 types.
- 6) At the vascularization stage of corpora lutea of this group, new arterioles protrude actively from the capsule into the lutein cell layer, and at the fully-formed stage these arterioles reach as far as in the deep portions of the lutein

cell layers. At the beginning stage of the regressive process, normal arterioles with the marked internal elastic membrane are found in the periphery of the lutein cell layer. Arterioles with arteriosclerotic changes appear at the middle stage of the regressive process for the first time; namely relatively large arterioles under the capsule show increase of elastic fibers in the intermediate coat. At the last stage, with hyalinization of the interstitial tissues, arterioles themselves undergo hyaline swelling of the wall, and collapse gradually.

7) Vascular bodies were divided into 3 types.

8) Arterioles found in the vascular bodies show heavy arteriosclerotic changes in comparison with those of corpora lutea of non-pregnancy: that is to say they are found with conspicuous thickening of the internal elastic membrane and hyperplastic swelling of the inner coat. Only such arterioles remain in spite of the disappearance of lutein cells and of interstitial tissues according to the hyalinization, showing characteristic appearances as vascular bodies.

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#### REFERENCES

- 1) ANDERSON, H. (1926): *Contr. Embryol. Carneg. Inst.*, **17**, 107.
- 2) BABA, M. (1956): *Nichidai Igk. Z.*, **15**, 869 (in Japanese).
- 3) BÖSHAGEN, A. (1904): *Zschr. Geburtsh. Gynäk.*, **53**, 323.
- 4) CLARK, J. G. (1900): *Johns Hopk. Hosp. Rep.*, **9**, 594.
- 5) CORNER, G. W. (1919): *Amer. J. Anat.*, **26**, 117.
- 6) DUKE, K. L. (1945): *Anat. Rec.*, **91**, 8.
- 7) DUKE, K. L. (1947): *Ibid.*, **98**, 507.
- 8) GRUBE (1902): *Zbl. Gynäk.*, **25**, 673.
- 9) HAMMOND, J. (1927): *The Physiology of Reproduction in the Cow*, Cambridge: Cambridge University Press.
- 10) HARRISON, R. J. (1948): *Biol. Rev.*, **23**, 296.
- 11) IMAGAWA, Y. (1936): *Hokuetsu Igk. Z.*, **51**, 546 (in Japanese).
- 12) ISONO, T. (1932): *Okayama Igk. Z.*, **44**, 2727 (in Japanese).
- 13) MCNUTT, G. W. (1924): *J. Amer. vet. med. Ass.*, **65**, 556.
- 14) MATSUOKA, S. (1955): *Sōgō Igaku*, **12**, 221 (in Japanese).
- 15) MAXIMOW, A. & W. BLOOM (1952): *A Textbook of Histology*, 6th Ed., Philadelphia & London: W. B. Saunders Co.
- 16) NISHIMURA, S. (1956): *Nichidai Igk. Z.*, **15**, 878 (in Japanese).
- 17) ONO, Y. (1955): *Ibid.*, **14**, 1343 (in Japanese).
- 18) PANKOW, O. (1906): *Arch. Gynaek.*, **80**, 271.
- 19) SAITO, O. (1926): *Okayama Igk. Z.*, **38**, 431 (in Japanese).

- 20) SOHMA, M. (1908): *Arch. Gynaek.*, **84**, 377.  
 21) TAKAHATA, K., N. KUDO, K. FURUHATA, M. SUGIMURA, T. YAMASHITA, M. ABE & T. ITO (1957): *Jap. J. Zoottech. Sci.*, **28**, 307 (in Japanese).  
 22) TSUJIMURA, K. (1936): *Hokuetsu Igk. Z.*, **51**, 32 (in Japanese).  
 23) WOLTKE, W. (1900): *Beitr. path. Anat.*, **27**, 575.  
 24) YAMASHITA, T. (1959): *Jap. J. vet. Res.*, **7**, 177.  
 25) YAMASHITA, T. (1960): *Ibid.*, **8**, 107.

## EXPLANATION OF PLATES

## PLATE I. Arterioles Found in Various Structures of Ovaries

WEIGERT's stain × 370

Fig. 1.	Type 1	Fig. 8.	Type 8
Fig. 2.	Type 2	Fig. 9.	Type 9
Fig. 3.	Type 3	Fig. 10.	Type 10
Fig. 4.	Type 4	Fig. 11.	Type 11
Fig. 5.	Type 5	Fig. 12.	Type 12
Fig. 6.	Type 6	Fig. 13.	Type 13
Fig. 7.	Type 7	Fig. 14.	Type 14

## PLATE II. Normal Vesicular Follicle (EF.), Atretic Follicles (Eaf.), Corpora Lutea of Non-pregnancy (EL.) and Vascular Bodies (Eg.)

WEIGERT's stain

Fig. 15.	EF.	× 350	Fig. 20.	EL. IV.	× 70
Fig. 16.	Eaf. I.	× 350	Fig. 21.	EL. VI.	× 70
Fig. 17.	Eaf. II.	× 350	Fig. 22.	Eg. I.	× 70
Fig. 18.	Eaf. III.	× 350	Fig. 23.	Eg. II.	× 70
Fig. 19.	EL. II.	× 70	Fig. 24.	Eg. III.	× 70



