A Study on the Lymphatic Apparatus in the Pancreas of Macaca cyclopis, with Special Reference to the Development*

By

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Introduction

By reviewing the literatures so far published on this subject, Krause (1922) stated that occasionally lymphollicles had been discovered in the interstitial connective tissue of the pancreas of doves. Hellman (1927), in addition, reported the existence of lymphatic apparatus in human pancreas. Furthermore, Matsuoka (1944) confirmed these discoveries by the above authors, and at the same time, carefully extended the scope of study on the distribution of lymphatic tissue on mammals, birds, reptiles, amphibia and other various vertebrates. The results revealed that lymphatic apparatus would not appear in the pancreas of primates. Even among mammals, only in rabbits was there a few lymphatic infiltrations which were distributed in the interstitial connective tissue of the pancreas.

In contrary to these findings, lymphatic infiltrations and solitary nodules usually showed better development in the pancreas of birds and those vertebrates which were lower in class. According to Ogamma (1955), in the pancreas of human fetus the lymphatic apparatus mostly appeared as lymphatic infiltration and solitary nodules.

The author has definitely detected the existence of lymphatic apparatus in the pancreas of adult monkeys in this study, and has further followed the progress during its development. Those interesting findings are therefore presented in this paper.

Materials and Method

Ten Macaca cyclopis were used as the study subjects. They were 24 and 48 hours after birth, and also at the approximate ages of 6,

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11, 16, 20, 28, 36, 48 and 60 months. Somatometry for the sitting height, height, length of tails, body weight, breadth of shoulders, trunk length, length of limbs, etc. were performed. The results obtained were compared with that by Schultz on the Rhesus monkeys and the age of these monkeys were thus estimated.

10% formalin was sufficiently injected through the abdominal aorta under Ravonal narcosis on all subjects. Then the subjects were immersed and preserved in the same solution. After fixation, the whole pancreas were removed and embedded in celloidin. Serial sections along the long axis were made for the microscopical examination.

For the convenience of recording, the age distribution of the Macaca cyclopis was classified according to Harm's report (1956); i.e. for those within two weeks after birth were designated as in the lactation period; for those within 6 months, infantile period; and for those within 3-4 years, juvenile period.

**Results**

**Case 1.** Macaca cyclopis (0.35 kg), female. 24 hours after birth.

Pancreas (0.41 g). The outer margin of the pancreas was wrapped with capsule of thick fibrous connective tissue. From the capsule, the septa of connective tissue of uncertain sizes enter to and for towards the inner parts of the organ to divide the parenchyma into a number of lobules of various sizes. Inside the lobules, here was thickly observed distribution of terminal portion, in which cell was pyramidal in shape, containing a light round nucleus. Intercalated duct was composed of lightly stained simple cuboidal epithelium, and generally was short. Various sizes of branch of ducts ran everywhere of the interlobular connective tissue. These ducts were composed of simple cuboidal epithelium or simple columnar epithelium, in the wall associated with membrane of muscle fiber. Pancreatic duct of this case was relatively thick and composed of simple cuboidal epithelium and well developed lamina propria with few muscle fibers. No lymphatic apparatus could be observed in this case.

**Case 2.** Macaca cyclopis (0.45 kg), male. 48 hours after birth.

Pancreas (0.46 g). In this case, the microscopical finding was not significantly different in comparision with the previous one. No lymphatic apparatus could be found in pancreas in this case.

**Case 3.** Macaca cyclopis (1.0 kg), male. 6 months old.

Pancreas (2.0 g). In this case, generally the lobules were large in size with rich interlobular connective tissue. A few oval cells were found in the lumen of terminal portion. Long intercalated portion, which was formed by the simple squamous epithelium, is
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predominant in the lobules. Branch of the ducts in interlobular connective tissue was formed by simple columnar epithelium surrounded by connective tissue with small amount of muscle fiber and this in turn formed a thicker lamina propria. Pancreatic duct consists of high columnar epithelium, well developed lamina propria and thin layer of circular muscle fibers in the adjacent area. No lymphatic apparatus was found in this case.

Case 4. Macaca cyclopis (1.5 kg), male. 11 months old.
Pancreas (3.0 g). The histological structure was not significantly different from case 3. No lymphatic apparatus could be found in this case.

Case 5. Macaca cyclopis (1.9 kg), male. 16 months old.
Pancreas (3.9 g). In this case, four lymphatic apparatus were found.
A) Head of pancreas—Four lymphatic infiltrations about 180 x 120 x 80—120 x 80 x 60μ in size were found. They were all developed in the interlobular connective tissue, especially in the tunica adventitia of the medium or small bifurcated duct (Fig. 1).

B) Body of pancreas—No lymphatic apparatus was found.
C) Tail of pancreas—No lymphatic apparatus was found.

Case 6. Macaca cyclopis (2.0 kg), male. 20 months old.
Pancreas (4.5 g). Eighteen lymphatic infiltrations were found.
A) Head of pancreas—Eighteen lymphatic infiltrations about 550 x 200 x 210—80 x 50 x 90μ in size were found. These infiltrations were all located along extralobular bifurcated duct or pancreatic duct. Most of them were found in the tunica adventitia, occasionally seen at the connective tissue of lamina propria. Those lymphatic infiltrations showed some relationship with small veins and lymphatic vessels (Figs. 2-4):

B) Body and tail of pancreas—No lymphatic apparatus could be detected in this region.

Case 7. Macaca cyclopis (2.6 kg), female. 28 month old.
Pancreas (5.5 g). Eight lymphatic infiltrations and one solitary nodule were found in the whole area of the pancreas.
A) Head of pancreas—Five lymphatic infiltrations about 370 x 220 x 240—190 x 100 x 120μ in size were found. One of them was found in the intralobular connective tissue, connected with intercalated portion and small veins. The others were mainly located in the tunica adventitia of the diverging part of the interlobular duct or in pancreatic ducts. The majority of them showed some relationship with lymphatic vessels and small blood vessels (Fig. 5).

One solitary nodule, about 400 x 220 x 300μ in size was found and it was located at the border zone between the inter- and intralobular
parts surrounding the diverging part of the small duct, and was
developed in the connective tissue along the lymphatic vessels and
small veins. Neither formation of secondary nodule nor differenti-
ation of germinal center could be detected from the solitary nodules
(Fig. 6).

B) Body of pancreas—One lymphatic infiltration about 230 ×
150 × 120μ in size was found. This apparatus developed in the con-
nective tissue of the border zone between the inter- and intralobular
parts and closely contacted with the diverging parts of small ducts
and small veins.

C) Tail of pancreas—Two lymphatic infiltrations about 300 ×
150 × 240 — 220 × 150 × 120μ in size were found. One of them appeared
in the small bifurcated duct in the border zone between the inter-
and intralobular portions. The other one appeared in the tunica
adventitia of the medium sized bifurcated duct in the connective
tissue and it was associated with small veins.

Case 8. Macaca cyclopis (3.2 kg), male. 36 months old.
Pancreas (7.0 g). Eight lymphatic apparatus were found and all
of them were lymphatic infiltrations.

A) Head of pancreas—Five lymphatic infiltrations about 420 ×
120 × 580 — 220 × 80 × 270μ in size were found. All of these apparatus
distributed in extralobular part, mostly appeared in the tunica ad-
ventitia of the medium sized bifurcated ducts and pancreatic ducts,
only occasionally seen in lamina propria. In general, the lymphatic
infiltrations showed some relationship with the lymphatic vessels and
small veins (Fig. 7).

B) Body of pancreas—Two lymphatic infiltrations about 200 ×
150 × 210 — 120 × 80 × 150μ in size were found. All of them were dis-
tributed in interlobular connective tissue and most of them could be
found in the tunica adventitia of the diverging part of the small or
medium sized ducts. These infiltrations were invariably in close
contact with small vessels and lymphatic vessels (Fig. 8).

C) Tail of pancreas—One lymphatic infiltration about 190 × 100 ×
150μ in size was found. It ran along the extralobular part and it
was developed from the tunica adventitia of the diverging part of
the small duct. It was also connected with small veins.

Case 9. Macaca cyclopis (4.4 kg), female. 48 months old.
Pancreas (7.0 g). Eleven lymphatic infiltrations were found.

A) Head of pancreas—Three lymphatic infiltrations about 220 ×
70 × 120 — 160 × 70 × 120μ in size were found in the tunica adventitia
of the medium or small sized bifurcated duct in the interlobular
connective tissue. Rarely they could be found in lamina propria. All
were in close contact with lymphatic vessels or small veins (Fig. 9).
B) Body of pancreas—Two lymphatic infiltrations about $370 \times 90 \times 90 - 220 \times 80 \times 150 \mu$ in size were found. These lymphatic apparatus usually appeared in the connective tissue of the tunica adventitia of interlobular bifurcated duct. Both were related with lymphatic vessels.

C) Tail of pancreas—Six lymphatic infiltrations about $300 \times 190 \times 160 - 160 \times 90 \times 150 \mu$ in size were found. All of the lymphatic infiltrations were found in the tunica adventitia of the medium sized bifurcated duct within extralobular connective tissue. They were associated with lymphatic vessels (Fig. 10).

**Case 10.** Macaca cyclopis (5.3 kg), female, 60 month old.

Pancreas (7.5 g). Fifteen lymphatic infiltrations were found.

A) Head of pancreas—Two lymphatic infiltrations about $1400 \times 100 \times 120 - 140 \times 70 \times 120 \mu$ in size were found. All were developed in the interlobular connective tissue. They were found in tunica adventitia of pancreatic ducts and in the lamina propria of small ducts in connection with small veins (Fig. 11).

B) Body of pancreas—Nine lymphatic infiltrations about $210 \times 140 \times 210 - 130 \times 60 \times 90 \mu$ in size were found. Most of the lymphatic apparatus were developed in the tunica adventitia or lamina propria of the medium or small sized interlobular bifurcated ducts. These lymphatic infiltrations were mainly developed along the lymphatic vessels or small veins. One lymphatic infiltration appeared in the border zone between the inter- and intralobular portions, and was seen at the tunica adventitia of medium sized ducts.

C) Tail of pancreas—Four lymphatic infiltrations about $370 \times 220 \times 300 - 70 \times 60 \times 90 \mu$ in size were found. Two of them spread along the intercalated ducts in the intralobular connective tissue. The other two accompanied with small ducts and small veins were found in the connective tissue of the border zone between the inter- and intralobular portions (Fig. 12).

**Discussion and Conclusion**

In the present study, the author has used Macaca cyclopis in different age groups as the subjects to examine in detail the formation and distribution of the lymphatic apparatus in their pancreas. In brief, the following results were obtained:

1. In the pancreas of mature Macaca cyclopis, the existence and distribution of lymphatic apparatus were definitely recognized and its developmental basis was clarified.

2. In the lactation and infantile periods, however, the lymphatic apparatus could not be found. Lymphatic infiltrations were first
found after 16 months, the juvenile period. According to previous literature, similar findings were found in the large oral glands of Macaca cyclopis, but in the human pancreas lymphatic apparatus were developed in earlier period, i.e. in 6th month fetus.

3. In the pancreas of Macaca cyclopis, the lymphatic apparatus which first appeared in the head portion, are gradually increased and extend to the whole area of pancreas with the increasing age.

4. The lymphatic apparatus of the pancreas of Macaca cyclopis, generally accompanied with the differentiation of solitary nodules, showed the increasing tendency through the whole juvenile period and until reaching the adulthood. The development of such lymphatic apparatus was essentially consistent with the findings in human pancreas during the fetal stage of development.

5. Through the cases, it has been found that in the interlobular connective tissue of the pancreas of Macaca cyclopis there were the concentrated and prominent distribution of the lymphatic apparatus, rapidly decreasing in number from here toward the inner part of the lobules. Very similar findings were also found in the pancreas of human fetus. In contrary to this, lymphatic apparatus showed remarkable development within the lobules in the large oral glands of monkeys.

6. Among all the cases of Macaca cyclopis, their lymphatic apparatus and the glandular ducts were, with no exception, interrelated and most of the lymphatic apparatus were developed in the diverging part of excretory ducts. In addition to this, most of the apparatus were also in close contact with veins and lymphatic vessels.

7. In the lymphatic apparatus of the pancreas in Macaca cyclopis, just like those in the case of human fetus, the formation and differentiation of the secondary nodules or germinal center could not be found.

References

Plate
Explanation of figures

(Plate I, II)

Fig. 1. Lymphatic infiltration, which develops in the tunica adventitia of small excretory duct in the extralobular connective tissue, in close contact with lymphatic vessel. Head of pancreas, case 5. ×280.

Fig. 2. Lymphatic infiltration, which spreads in the tunica adventitia of bifurcated duct in interlobular connective tissue. Head of pancreas, case 6. ×100.

Fig. 3. Lymphatic infiltration, which surrounds the small bifurcated duct in the interlobular connective tissue. Head of pancreas, case 6. ×100.

Fig. 4. Lymphatic infiltration, which develops in the lamina propria of pancreatic duct. Head of pancreas, case 6. ×100.

Fig. 5. Lymphatic infiltration, which surrounds a lymphatic vessel in the tunica adventitia of pancreatic duct. Head of pancreas, case 7. ×100.

Fig. 6. A solitary nodule, which surrounds a small bifurcated duct in the border zone between the inter- and intralobular parts. Head of pancreas, case 7. ×100.

Fig. 7. Lymphatic infiltration, which develops in the lamina propria of pancreatic duct. Head of pancreas, case 8. ×100.

Fig. 8. Lymphatic infiltration coming in contact with the small bifurcated duct in interlobular part. Body of pancreas, case 8. ×100.

Fig. 9. Lymphatic infiltration, which is seen near a small bifurcated duct in the interlobular connective tissue. Head of pancreas, case 9. ×100.

Fig. 10. Lymphatic infiltration, which appears in the tunica adventitia of interlobular duct. Tail of pancreas, case 9. ×100.

Fig. 11. Subepithelial lymphatic infiltration, which appears in the lamina propria of pancreatic duct. Head of pancreas, case 10. ×100.

Fig. 12. Lymphatic infiltration, which spreads along the intercalated duct in the border zone between the inter- and intralobular parts. Tail of pancreas, case 10. ×100.