

Research Article

**MICROMETRICAL STUDIES ON THE SEQUENTIAL GROWTH OF THE
PRENATAL LIVER OF GOAT (*CAPRA HIRCUS*)**

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ABSTRACT: The present study was conducted on the liver of goat foeti at various prenatal ages viz Group I (below 50 days), Group II (between 50-100 days) and Group III (above 100 days) containing 6 number of foeti in each group to study the growth of the same organ in terms of its micrometrical attributes. The mean values for thickness of capsule and diameter of central vein in right, left, caudate and quadrate lobes differed significantly ($p<0.05$) between groups II and group III. Again, the mean values for nuclear diameter of hepatocytes in right and left lobe differed significantly ($p<0.05$) between all the age groups. Caudate and quadrate lobes could not be detected in the animals of age group I. However, nuclear diameter of hepatocytes in these lobes did not differ significantly between groups II and III. The mean values for number of hepatocytes per field in left lobes differed significantly ($p<0.05$) between groups I and II. The number of hepatocytes per field in respect of right lobes did not differ significantly in all the age groups.

Key words: Micrometry, Liver, Prenatal goat.

INTRODUCTION

Liver is one of the vital organs which is actively involved in various metabolic functions of the body such as metabolism of proteins, lipids, carbohydrates, vitamin A, vitamin B, synthesis of fibrinogen, globulin, albumin clotting factors, secretion of bile, storage of glycogen, fat, excretion of urea, uric acids. It is also involved in other functions such as detoxification of various metabolic wastes and drugs (Dona 2007).

During embryonic life once the liver bud is generated and the hepatoblast from the foregut invade the septum transversum mesenchyme, the cells within the embryonic liver environment organizes to generate the complex hepatic architecture that is so crucial for normal liver function (Zhao and Duncan 2005). Again, during the mid-gestation stages of development, the hepatoblast population must expand to define the total volume of the liver.

Documentation of normal embryonic and fetal development is necessary to understand the consequences of harmful influences at various stages of gestation (Evans

and Sack 1973). A number of histological and histochemical studies had been carried out in the adult liver. But the literature available on the prenatal liver, especially in goat is very less. Studies on prenatal development of the liver had been conducted in sheep (Ledyava 1973), mouse (Li *et al.* 2004), non-descript Indian buffalo (Doley *et al.* 2006), cat (Canfield and Johnson 2007). Paucity of literature on micrometrical development of the prenatal liver in goats and the importance of this aspect prompted the present study.

MATERIALS AND METHODS

The present study was conducted on the liver of 18 goat foeti which were collected from the slaughter houses in and around Jammu city. These foeti were ranged from early pregnancy to near full term. Immediately after collection, the umbilical cords of these foeti were ligated properly and were cleaned with cotton soaked with water to remove the amniotic fluid. The weight of each foeti was recorded with the help of analytical balance. The approximate age of the foeti were calculated by putting

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the body weight values in the formula postulated by Singh *et al.* (1979) for estimation of age in goat foetus, as mentioned below

$$W^{1/3} = 0.096 (t-30).$$

Where, W= body weight of foetus in gm.
t= age of the foetus in days.

The collected foetii were then divided into three groups based on their estimated ages *viz.* Group I (below 50 days), Group II (between 50-100 days) and Group III (above 100 days) containing 6 number of foeti in each group.

Liver tissue samples were collected one from each lobe and fixed in 10% Neutral Buffered Formalin solution (Luna 1968). After achieving complete fixation, tissues were processed for paraffin block preparation by alcohol-benzene schedule (Luna 1968). Tissue sections of 5-6 μm thickness were obtained from these blocks on clean glass slides with the help of rotary microtome. The sections were stained with Hematoxylin & Eosin and various micrometrical parameters of the liver of goat foeti were recorded with the help of ocular micrometer duly calibrated with stage micrometer.

RESULTS AND DISCUSSION

Thickness of capsule

The various measurements in regard to thickness of capsule, diameter of central vein, nuclear diameter of hepatocytes and number of hepatocytes per field have been depicted in Table 1 to Table 4.

In the present study, for right lobe the mean thickness of the capsule ranged from $3.24 \pm 0.43 \mu\text{m}$ to $4.11 \pm 0.51 \mu\text{m}$, maximum thickness of the capsule being recorded at 89 days of gestation. For left lobe, the mean thickness of the capsule ranged from $3.51 \pm 0.50 \mu\text{m}$ to $4.11 \pm 0.31 \mu\text{m}$, the maximum thickness of the capsule being recorded at 89 days of gestation. In caudate lobe, the mean thickness of the capsule ranged from $3.51 \pm 0.38 \mu\text{m}$ to $4.21 \pm 0.19 \mu\text{m}$, maximum thickness of the capsule was recorded at 89 days of gestation. Similarly, for quadrate lobe the same ranged from $3.31 \pm 0.32 \mu\text{m}$ to $4.11 \pm 0.39 \mu\text{m}$ and the maximum thickness of the capsule being found at 89 days of gestation. However, the variation in respect of thickness of capsule in different lobes of liver was not found to be significant at various prenatal ages.

Likewise, in respect of goat foeti of group-3, the mean thickness of the capsule ranged from $4.42 \pm 0.30 \mu\text{m}$ to $6.48 \pm 0.39 \mu\text{m}$, maximum thickness of the capsule being recorded at 148 days of gestation. In left lobe, the mean thickness of the capsule ranged from $4.29 \pm 0.51 \mu\text{m}$ to

$6.51 \pm 0.51 \mu\text{m}$, the maximum thickness of the capsule being recorded at 148 days of gestation. In caudate lobe, the mean thickness of the capsule ranged from $4.38 \pm 0.42 \mu\text{m}$ to $6.65 \pm 0.29 \mu\text{m}$, maximum thickness of the capsule was recorded at 148 days of gestation. Similarly, for quadrate lobe, the same ranged from $4.51 \pm 0.32 \mu\text{m}$ to $6.51 \pm 0.51 \mu\text{m}$, the maximum thickness of the capsule being found at 148 days of gestation. However, the variation in respect of thickness of capsule in different lobes of liver was not found to be significant at various prenatal ages. Again, capsular thicknesses of the various lobes of liver in different age groups revealed that the mean values for thickness of capsule in right, left, caudate and quadrate lobes differed significantly ($p < 0.05$) between groups II and group III. The thickness of capsule in animals of group I could not be recorded as it was too thin to measure.

The mean values for thickness of capsule in various lobes of the liver in goat foeti increased significantly ($p < 0.05$) from group II to group III. Similar pattern of enhancement of capsular thickness was also recorded in buffalo foetii (Doley *et al.* 2006). Such increased thickness of the capsule might be for providing extra support to the increasing volume of the liver.

Diameter of central vein

The measurements for the diameters of central vein in various lobes of the liver of goat foeti in respect of group I revealed that for right lobe, the mean diameter of central vein ranged from $63.90 \pm 7.95 \mu\text{m}$ to $78.10 \pm 10.79 \mu\text{m}$, maximum diameter being recorded at 49 days of gestation. Similarly, for left lobe, the same ranged from $56.80 \pm 7.42 \mu\text{m}$ to $82.78 \pm 13.91 \mu\text{m}$, maximum being found at 49 days of gestation. However, the diameter of central vein of both right and left lobes of liver did not differ significantly between different prenatal ages.

The measurements for the diameter of central vein in various lobes of the liver of goat foeti of group II revealed that for right lobe, the mean diameter of central vein ranged from $71 \pm 8.94 \mu\text{m}$ to $89.88 \pm 11.36 \mu\text{m}$, maximum diameter of central vein being recorded at 89 days of gestation. In left lobe, the mean diameter of central vein ranged from $62.62 \pm 6.39 \mu\text{m}$ to $89.88 \pm 11.36 \mu\text{m}$, the maximum diameter being recorded at 89 days of gestation. Again, for caudate lobe, the mean diameter of central vein ranged from $63.9 \pm 8.66 \mu\text{m}$ to $73.27 \pm 4.26 \mu\text{m}$, maximum was recorded at 89 days of gestation. Similarly, for quadrate lobe, the same ranged from $71 \pm 10.36 \mu\text{m}$ to $78.1 \pm 10.79 \mu\text{m}$, the maximum being found at 82 days of gestation. However, the variation in respect of diameter of central vein in different lobes of liver was not found

Table 1. Thickness of the capsule in various lobes of the liver of goat foeti in different prenatal age groups (Mean \pm SE in μm).

| Group | Right lobe | Left lobe | Caudate lobe | Quadrat lobe |
|---------|------------------------------|------------------------------|------------------------------|------------------------------|
| Group 1 | N | N | N | N |
| Group 2 | 3.63 ^a \pm 0.43 | 3.58 ^a \pm 0.39 | 3.79 ^a \pm 0.38 | 3.65 ^a \pm 0.38 |
| Group 3 | 5.52 ^b \pm 0.32 | 5.46 ^b \pm 0.46 | 5.53 ^b \pm 0.41 | 5.59 ^b \pm 0.45 |

[Mean with at least one common super script do not differ ($p<0.05$) significantly. N= thickness of capsule could not be recorded].

to be significant at various prenatal ages.

The measurements for diameters of central vein in various lobes of the liver of goat foeti of group-III revealed that for right lobe, the mean diameter of central vein ranged from 73.27 ± 8.52 μm to 108.77 ± 17.04 μm , maximum diameter of central vein being recorded at 102 days of gestation. For left lobe, the mean diameter of central vein ranged from 75.68 ± 6.95 μm to 101.67 ± 9.94 μm , the maximum diameter being recorded at 102 days of gestation also for caudate lobe, the mean diameter of central vein ranged from 75.26 ± 6.95 μm to 104.08 ± 18.17 μm , maximum being recorded at 102 days of gestation. Similarly, for quadrat lobe, the same ranged from 73.27 ± 9.94 μm to 99.4 ± 12.07 μm , the maximum being found at 102 days of gestation. However, the variation in respect of diameter of central vein in different lobes of liver was not found to be significant at various prenatal ages.

Again, the mean values for diameter of central vein in left lobe differed significantly ($p<0.05$) between groups II and III. Similar pattern of hepatic growths were reported in pre hatched broiler chick liver (Pal *et al.* 1991), buffalo foeti and goat foeti (Kumar *et al.* 2007). However, no significant variation was recorded in regard to this parameter in right lobe of the liver in all the age groups. Caudate and quadrat lobes could not be detected in the animals of group-I. However, diameter of central vein in caudate lobe differed significantly ($p<0.05$) between groups II and III.

Nuclear diameter of hepatocytes

The measurements for the nuclear diameters of the hepatocytes in various lobes of the liver of goat foetii of group-I revealed that for right lobe, the mean nuclear diameter of the hepatocytes ranged from 5.89 ± 0.39 μm to 6.53 ± 0.32 μm , maximum diameter being recorded at 49 days of gestation. Similarly, for left lobe, the same ranged from 6.06 ± 0.49 μm to 6.24 ± 0.35 μm , maximum being found at 45 days of gestation. However, the nuclear diameter of the both right and left lobes of liver did not differ significantly between different prenatal ages.

The measurements for the nuclear diameters of the hepatocytes in various lobes of the liver of goat foetii of group II revealed that for right lobe, the mean nuclear diameter of the hepatocytes ranged from 6.06 ± 0.39 μm to 6.78 ± 0.28 μm , maximum nuclear diameter of the hepatocytes being recorded at 82 and 89 days of gestation in respect of left lobe, the mean nuclear diameter of the hepatocytes ranged from 6.28 ± 0.49 μm to 6.64 ± 0.21 μm , maximum values being recorded at 89 days of gestation. For caudate lobe, the mean nuclear diameter of the hepatocytes ranged from 6.64 ± 0.46 μm to 6.78 ± 0.42 μm , maximum nuclear diameter of the hepatocytes was recorded at 89 days of gestation. Similarly, for quadrat lobe, the same ranged from 6.42 ± 0.39 μm to 6.78 ± 0.24 μm , the maximum nuclear diameter of the hepatocytes being found at 89 days of gestation. However, the nuclear diameter of all the lobes of liver did not differ significantly between different prenatal ages.

The measurements for the nuclear diameters of the hepatocytes in various lobes of the liver of goat foeti pertaining to group-III revealed that for right lobe, the mean nuclear diameter of the hepatocytes ranged from 6.78 ± 0.28 μm to 7.31 ± 0.32 μm , maximum nuclear diameter of the hepatocytes being recorded at 145 days of gestation. For left lobe, the mean nuclear diameter of the hepatocytes ranged from 6.64 ± 0.46 μm to 6.96 ± 0.35 μm , the maximum nuclear diameter of the hepatocytes being recorded at 122 days of gestation. For caudate lobe, the mean nuclear diameter of the hepatocytes ranged from

Table 2. Inter central vein distance in various lobes of the liver of goat foetii in different prenatal age groups (Mean \pm SE in μm).

| Group | Right lobe | Left lobe | Caudate lobe | Quadrat lobe |
|---------------|----------------------|----------------------|---------------------|----------------------|
| Group 1 (N=6) | $345.06^a \pm 6.81$ | $358.12^b \pm 14.34$ | NP | NP |
| Group 2 (N=6) | $388.79^a \pm 17.60$ | $410.09^a \pm 12.63$ | $409.38^a \pm 7.1$ | $416.48^a \pm 8.09$ |
| Group 3 (N=6) | $449.99^b \pm 10.22$ | $456.67^a \pm 20.44$ | $447.3^a \pm 23.71$ | $436.22^a \pm 20.16$ |

Mean with at least one common super script do not differ ($p<0.05$) significantly. NP = not present.

Table 3. Nuclear diameter of hepatocytes in various lobes of the liver of goat foetii in different prenatal age groups (Mean \pm SE in μm).

| Group | Right lobe | Left lobe | Caudate lobe | Quadrata lobe |
|---------------|------------------------------|------------------------------|-----------------------------|------------------------------|
| Group 1 (N=6) | 6.10 ^a \pm 0.07 | 6.10 ^a \pm 0.03 | NP | NP |
| Group 2 (N=6) | 6.46 ^b \pm 0.10 | 6.42 ^b \pm 0.03 | 6.7 ^a \pm 0.03 | 6.64 ^a \pm 0.10 |
| Group 3 (N=6) | 6.92 ^c \pm 0.07 | 6.74 ^c \pm 0.03 | 6.7 ^a \pm 0.10 | 6.89 ^a \pm 0.03 |

Mean with at least one common super script do not differ ($p<0.05$) significantly. NP = not present.

6.64 \pm 0.35 μm to 6.99 \pm 0.21 μm , maximum was recorded at 145 days of gestation. Similarly, for quadrata lobe, the same ranged from 6.81 \pm 0.28 μm to 6.99 \pm 0.21 μm , the maximum being found at 134 and 148 days of gestation. The values for nuclear diameter of hepatocytes in various lobes of the liver of goat foeti did not differ significantly at various prenatal ages except in regard to caudate lobe, in which the values showed significant ($p<0.05$) variation at different prenatal ages. Doley *et al.* (2006) reported the nuclear diameter of the hepatocytes to be 6.18 \pm 0.05 μm at 46 to 105 days of gestation in buffalo foetii. Again Kumar *et al.* (2007) recorded the mean nuclear diameter of hepatocytes as 6.30 μm in goat foetii (92 to 138 days of gestation), which more or less corroborates with the present findings.

Again, the mean values for nuclear diameter of hepatocytes in right and left lobe differed significantly ($p<0.05$) between all the age groups. Caudate and quadrata lobes could not be detected in the animals of age group I. However, nuclear diameter of hepatocytes in these lobes did not differ significantly between groups II and III.

Number of hepatocytes per field

The measurements for number of hepatocytes per field in various lobes of the liver of goat foetii of group I revealed that for right lobe, the mean number of hepatocytes per field ranged from 72.33 \pm 4.66 to 111.33 \pm 6.49, maximum number of hepatocytes per field being recorded at 45 days of gestation. Similarly, for left

lobe, the same ranged from 51 \pm 4.80 to 114.16 \pm 4.89 and the maximum value was found at 49 days of gestation. In group I, the values for number of hepatocytes per field in right and left lobes differed significantly ($p<0.05$) between various prenatal ages.

The measurements for number of hepatocytes per field in various lobes of the liver of goat foeti of group II revealed that for right lobe, the mean number of hepatocytes per field ranged from 85 \pm 9.67 to 134.83 \pm 10.88, maximum number of hepatocytes per field being recorded at 89 days of gestation. For left lobe, the mean number of hepatocytes per field ranged from 105.16 \pm 7.9 to 138.5 \pm 13.57, the maximum number of hepatocytes per field being recorded at 82 days of gestation. Again, for caudate lobe the mean number of hepatocytes per field ranged from 86.83 \pm 9.02 to 116.33 \pm 7.70, maximum number of hepatocytes per field was recorded at 89 days of gestation. Similarly, for quadrata lobe the same ranged from 91.16 \pm 7.83 to 115.16 \pm 6.09, the maximum number of hepatocytes per field was recorded at 89 days of gestation. In this group also, the values for number of hepatocytes per field in right and left lobes differed significantly ($p<0.05$) between various prenatal ages. Liman (1996) reported the number of hepatocytes per unit area to be 107.48 \pm 6.63 at 84 days of gestation in sheep foeti. Again, Doley *et al.* (2006) recorded the mean number of hepatocytes per mm square area as 16.40 \pm 1.02 at 158 to 323 days of prenatal development in buffalo foeti.

In group-II, it was found that for right lobe, the mean

Table 4. Number of hepatocytes per field in various lobes of the liver of goat foetii in different prenatal age groups (Mean \pm SE in μm).

| Group | Right lobe | Left lobe | Caudate lobe | Quadrata lobe |
|---------------|-------------------|--------------------------------|-------------------|-------------------|
| Group 1 (N=6) | 90.94 \pm 6.17 | 85.30 ^a \pm 9.13 | NP | NP |
| Group 2 (N=6) | 104.25 \pm 7.32 | 118.16 ^b \pm 5.68 | 100.16 \pm 8.63 | 99.33 \pm 7.91 |
| Group 3 (N=6) | 91.36 \pm 10.14 | 99.94 ^{ab} \pm 7.26 | 105.88 \pm 8.65 | 94.77 \pm 16.37 |

Mean with at least one common super script do not differ ($p<0.05$) significantly. NP = not present.

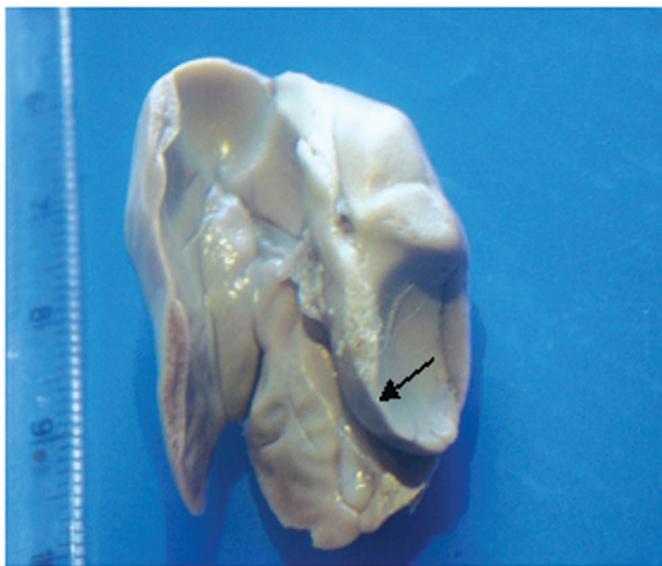


Fig. 1. Visceral surface of prenatal liver showing caudate lobe (arrow).

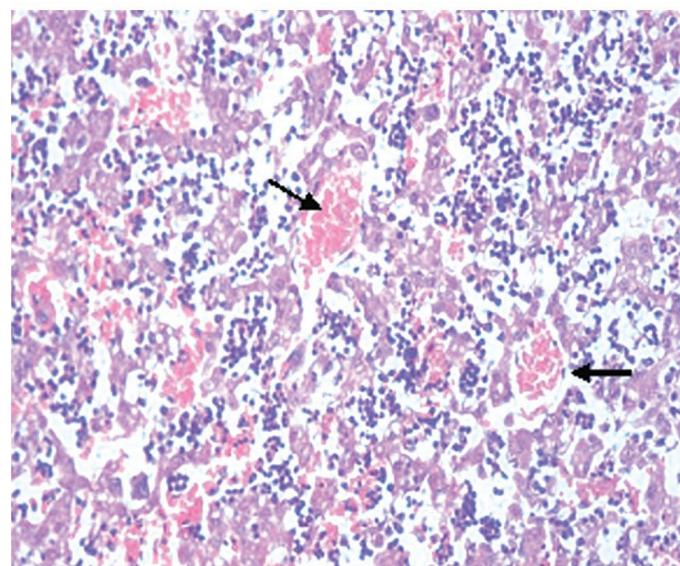


Fig. 2. Photomicrograph of 49 days old goat fetus (group-I). Showing developing central veins (arrows) and blood vessels of various shapes H&E, 200 X.

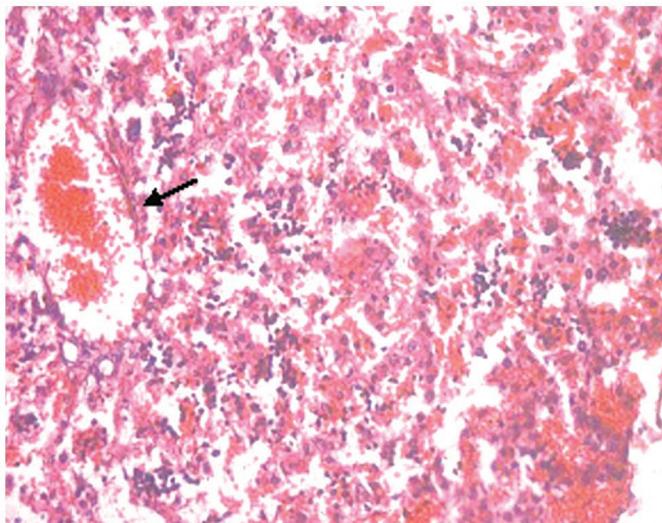


Fig. 3. Photomicrograph of 82 days old goat fetus (group-II). Showing well developed portal areas (arrow). H&E, 100 X.

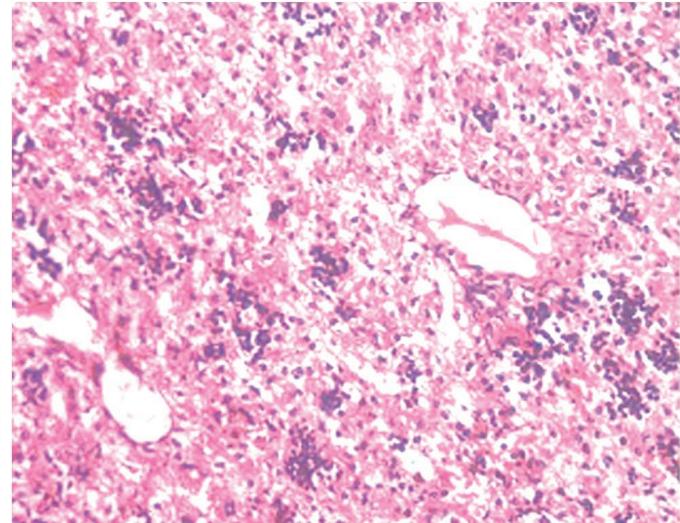


Fig. 4. Photomicrograph of 102 days old goat fetus (group-III). Showing typical arrangement of hepatocytes around the central vein. H&E, 100 X.

number of hepatocytes per field ranged from 55 ± 8.56 to 116.33 ± 7.89 , maximum number of hepatocytes per field being recorded at 148 days of gestation. For left lobe, the mean number of hepatocytes per field ranged from 79.50 ± 5.8 to 124.50 ± 4.72 , the maximum number of hepatocytes per field being recorded at 102 days of gestation. Again, for caudate lobe the mean number of hepatocytes per field ranged from 70 ± 5.82 to 122.66 ± 8.14 , maximum was recorded at 102 days of gestation. Similarly, in quadrate lobe, the same ranged from 64.16 ± 7.78 to 120.16 ± 4.99 , the maximum being found at 102 days of gestation. In group 3, the values for

number of hepatocytes per field in all the lobes of the liver showed a significant ($p < 0.05$) variation between different prenatal ages.

The mean values for number of hepatocytes per field in left lobes differed significantly ($p < 0.05$) between groups I and II. Caudate and quadrate lobes could not be detected in the animals of group I. However, number of hepatocytes in these lobes did not differ significantly between groups II and III. The values of number of hepatocytes per field in respect of right lobes did not differ significantly in all the age groups.

CONCLUSIONS

The present study observed that a significant growth of the liver in terms of thickness of capsule and diameter of central vein took place during the later part of gestation in goat. There was significant difference in terms of nuclear diameter of hepatocytes between the right and left lobes of the liver. The number of hepatocytes in the goat liver increased significantly during early gestation, but it was slow during the latter part of gestation.

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