Age related gross morphological studies on the thymus in postnatal Surti goat (*Capra hircus*)

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**ABSTRACT**

The gross studies were conducted on the thymus of 18 postnatal Surti goats. Three distinct parts of thymus were recognized viz., unpaired thoracic part, caudally situated paired body (cervical part) and right and left cranial parts from day old kid to 9 months. The cranial parts were not observed from the age of 12 months onwards. The caudal cervical part of thymus was gradually replaced by adipose tissue between 14 to 48 months, however, traces of thymus embedded within the adipose tissue was observed in cranial mediastinum even at the age of 48 months. The right limb of cervical thymus was slightly longer than the left limb in postnatal Surti goats. The maximum mean weight (26.850 ± 2.885 g) and volume (22.333 ± 2.275 cc) of thymus was recorded between 4 to 9 months. Relative weight of thymus was 0.39% in neonatal kids, which was much higher as compared to 0.015 % in adult Surti goats. Negative correlation was observed between age and weight of thymus during 12 to 48 months.

**Key words:** Adipose tissue, Biometry, Involution, Morphology, Thymus.

**INTRODUCTION**

Thymus is the first lymphoid organ to appear during embryonic development and is pre-requisite for the development of the other lymphoid organs such as spleen, lymph nodes and tonsils necessary for maturation of immunological competence (Hoshino et al., 1969). Failure to development of normal thymus structure can lead to defects ranging from immunodeficiency to autoimmune disease (Rodewald, 2008). Thus at birth the thymus is the most significant and the largest lymphatic organ and it has pace-maker function (Schummer et al., 1981). It begins to regress gradually until the animal reaches sexual maturity. Species, strain, and sex differences affect the involution of age-dependent thymic changes (Pearse, 2006). The present investigation was designed to elucidate the gross changes of thymus in postnatal Surti goats keeping in view the lack of literature on topic.

**MATERIALS AND METHODS**

The research materials used for present investigation include 18 postnatal Surti goats from a day old kid to 48 months of age irrespective of sex. The thymus was collected from apparently healthy Surti goats sacrificed at the local abattoirs of Navsari district, Gujarat. The weight of Surti goats was measured by physical balance before slaughter. The approximate age of the postnatal Surti goats was determined by dentition pattern (Noden and de Lahunta, 1985). The Surti goats were divided equally into three age groups based on their approximate age viz., group I (day old kid to 3 months), group II (4 to 9 months) and group III (12 to 48 months). The thymus from Surti goats were exposed by giving midline incision over sternum with superior extension into the neck up to the larynx. The thymus was studied *in-situ* position for its gross features and topographic relationship. After recording the gross observations, thymus was separated from the body by a careful dissection for biometrical observations. The weight of thymus was measured with the help of electronic balance. Length, width and thickness of the thymus were measured by Vernier caliper (Mitutoyo Caliper). The volume of thymus was measured by water displacement method resembling the Archimedes principle (Scherle, 1970). The data were statistically analysed by using one way ANOVA and means were compared using Duncan’s multiple range test (DMRT) and Student’s t-test (Snedecor and Cochran, 1994). The relative weight of thymus was calculated in per cent.

**RESULTS AND DISCUSSION**

**Gross morphology:** In the present investigation, the thymus was distinctly lobulated in group I and group II of postnatal Surti goats (Fig. 1), however, in group III, the lobulation was indistinct and surrounded by a connective tissue sheath. Such findings regarding lobulation were in accordance with those findings of Raghavan (1964) in ox and Schummer et al. (1981) in ruminants. The colour of fresh thymus was pale red in group I and group II, while it was pale red to pale white in group III postnatal Surti goats (Fig. 1). The white colour of thymus in adults might be due to infiltration of fat...
into thymic tissue in the process of involution. Similar findings were reported by other authors (Raghavan, 1964; Evans, 1993; Sarma et al., 2005).

In present study, the three distinct parts of thymus observed were unpaired thoracic part, caudally situated paired body (cervical part) and right and left cranial parts from the age of day old kid to 9 months old postnatal Surti goats (Fig. 1). The thoracic part of thymus in postnatal Surti goats was single irregularly quadrilateral in shape and located asymmetrically in the left side on the dorsal half of cranial mediastinum extended from the thoracic inlet to base of heart in group I and II of postnatal Surti goats (Fig. 2). Dorsally it was related to the vertebral column and thoracic part of longus colli muscle. Visceral surface was related to cranial vena-cava, brachiocephalic trunk and its branches, oesophagus, trachea and vagus nerves in each group. The parietal surface of thymus was partly covered by pleura and caudo-dorsal half of this surface covered by apical lobe of left lung. Ventrally it was related to the apical lobe of right lung. In these groups thymus can be found between the apical lobes of both lungs in left cranial mediastinum (Fig. 2). These findings were in accordance with the observations of Raghavan (1964) in ox and Schummer et al. (1981) in ruminants. In present work the thoracic part of thymus in group III postnatal Surti goats showed marked involutory changes. In this group as age advances the substantial amount of thymic tissue was replaced by the adipose tissue gradually, however, traces of thymus was still observed in cranial mediastinum at the age of 48 months in group III Surti goats (Fig. 3). Similar to our finding Schummer et al. (1981) reported presence of considerable amount of thymic tissue in the thorax even at five years of age in goat. Yugesh et al. (2014) also found thymus in pericardial mediastinum at the age of 8 to 9 months in hybrid pigs.

The cervical part was the longest part of thymus in postnatal Surti goats. The shape of the cervical thymus was roughly 'V' shaped with the point directed towards the thorax. It consisted of caudally situated paired body and right and left cranial parts. The body was paired, elongated in shape and lies on the ventral surface of the distal third of trachea in cervical region. It was related externally by the sternocaphalicus m. and sternothyrohyoideus muscle and either side bounded by the external jugular vein. It was linked caudally by single cervico-thoracic isthmus with the thoracic part at thoracic inlet and cranially by right and left limbs with cranial parts. The both limbs (right and left) which was extension of body run cranially as a thin lobulated strands at midline of trachea then passes on the lateral surfaces of the trachea at the upper half and finally terminate as a roughly triangular shape lobulated mass just behind the caudoventral aspect of mandibular salivary gland and lateral to the larynx on either sides. These lobulated masses termed as right and left cranial parts of cervical thymus. These findings were in
In the present work, whole thymus weight showed variable trends with relation to age groups in postnatal Surti goats. The mean weight of thymus decreases significantly (P<0.01) due to age dependent involution changes in thymus. Sandberg (1949) reported average maximum thymus weight 210 g, and 3.693 ± 0.279 g respectively. This result indicates that thymus grows maximum in group II, while in group III mean weight of thymus decreases significantly (P<0.01) due to age dependent involution changes in thymus. Sandberg (1949) reported average maximum thymus weight 210 g at puberty and 66 g at the age of 15 years in cow. Mishra et al. (1981) reported unpaired body (cervical part) of thymus gradually replaced by adipose tissue from the age of 14 to 48 months in postnatal Surti goats, however, small caudal cervical part was still observed just infront of sternum at later life of group III postnatal Surti goats. Pandey et al. (1970) reported complete disappearance of thymus in normal dog aged above 30 months. Contrary to these findings Evans (1993) stated that the evidence of a thymus can be seen in most dogs regardless of age. According to Radhakrishnan and Mariappa (1974) the free portions of the cervical part were first disappeared, while the thoracic part atrophied subsequently in Indian buffalo calves. Schummer et al. (1961) described that the thymus of lamb continued to grow at least the onset of sexual maturity (6 to 8 month) and involution was completed in two years of age in sheep. Trautmann and Fiebig (2002) described that involution of the thymus become pronounced at puberty in cattle and dogs. It was started from the cervical portions and remnants of the thoracic portion persist up to old age in these species. Ramaya et al. (2008) reported presence of all the three parts of thymus till the 3 months of postnatal life in buffalo calves. Thereafter, cranial portions disappeared usually by the age of 6 months. The cervical part (body) gradually disappeared by 12 months of age and whole thymus was replaced by adipose tissue at the age of 5 years. Present findings were in the line with those observed by various authors mentioned above in different domestic animals, however, age of involution vary in different domestic animals. This might be due to variation in factors like species, breed, sex, nutrition as well as steroid hormone levels. In addition to this possibility of accidental involution of thymus was also reported.

**Biometrical studies:** In the present work, whole thymus weight showed variable trends with relation to age groups in postnatal Surti goats. The mean weight in group I, II and III was 18.178 ± 1.794 g, 26.850 ± 2.885 g, and 3.693 ± 0.279 g respectively. This result indicates that thymus grows maximum in group II, while in group III mean weight of thymus decreases significantly (P<0.01) due to age dependent involution changes in thymus. Sandberg (1949) reported average maximum thymus weight 210 g at puberty and 66 g at the age of 15 years in cow. Mishra et al. (1981) reported unpaired body (cervical part) of thymus gradually replaced by adipose tissue from the age of 14 to 48 months in postnatal Surti goats, however, small caudal cervical part was still observed just infront of sternum at later life of group III postnatal Surti goats. Pandey et al. (1970) reported complete disappearance of thymus in normal dog aged above 30 months. Contrary to these findings Evans (1993) stated that the evidence of a thymus can be seen in most dogs regardless of age. According to Radhakrishnan and Mariappa (1974) the free portions of the cervical part were first disappeared, while the thoracic part atrophied subsequently in Indian buffalo calves. Schummer et al. (1961) described that the thymus of lamb continued to grow at least the onset of sexual maturity (6 to 8 month) and involution was completed in two years of age in sheep. Trautmann and Fiebig (2002) described that involution of the thymus become pronounced at puberty in cattle and dogs. It was started from the cervical portions and remnants of the thoracic portion persist up to old age in these species. Ramaya et al. (2008) reported presence of all the three parts of thymus till the 3 months of postnatal life in buffalo calves. Thereafter, cranial portions disappeared usually by the age of 6 months. The cervical part (body) gradually disappeared by 12 months of age and whole thymus was replaced by adipose tissue at the age of 5 years. Present findings were in the line with those observed by various authors mentioned above in different domestic animals, however, age of involution vary in different domestic animals. This might be due to variation in factors like species, breed, sex, nutrition as well as steroid hormone levels. In addition to this possibility of accidental involution of thymus was also reported.

**Table 1:** Gross biometrical Mean (± SE) with range of different parts of thymus at various age groups in postnatal Surti goats.

<table>
<thead>
<tr>
<th>Part of thymus</th>
<th>Group I (n=6)</th>
<th>Group II (n=6)</th>
<th>Group III (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length (cm)</strong></td>
<td><strong>Weight (gm)</strong></td>
<td><strong>F Value</strong></td>
<td><strong>P Value</strong></td>
</tr>
<tr>
<td>Cervico-thoracic isthmus</td>
<td>1.74 ± 0.32 (0.98-2.82)</td>
<td>1.89 ± 0.31 (1.14-2.68)</td>
<td>3.47 ± 0.45 (1.94-5.34)</td>
</tr>
<tr>
<td>Thickness (cm)</td>
<td>0.32 ± 0.12 (0.70-1.42)</td>
<td>0.39 ± 0.14 (0.86-2.12)</td>
<td>0.56 ± 0.10 (0.21-0.94)</td>
</tr>
<tr>
<td>Weight (gm)</td>
<td>6.87 ± 0.76 (4.53-9.82)</td>
<td>9.36 ± 1.22 (6.55-14.51)</td>
<td>4.36 ± 1.45 (2.03-7.16)</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>1.62 ± 0.27 (1.34-2.30)</td>
<td>2.20 ± 0.39 (1.68-3.60)</td>
<td>1.40 ± 0.75 (0.30-3.45)</td>
</tr>
<tr>
<td>Thickness (cm)</td>
<td>0.75 ± 0.12 (0.50-1.08)</td>
<td>0.54 ± 0.09 (0.32-0.86)</td>
<td>0.34 ± 0.10 (0.21-0.94)</td>
</tr>
</tbody>
</table>

Means bearing different superscript (a, b, c) in a row vary significantly (P<0.05); NA: Not applicable
double in thymus of male kids between 24 to 42 days of age. Cunningham et al. (2001) observed 42 gram of mean thymus weight at 2 weeks old lambs, while significant amount of thymus tissue (18 gram) was present even at the age of 3 to 4 years in sheep. Ramayya et al. (2008) recorded maximum weight (166 gram) of thymus in postnatal buffalo calves at 3 months of age and thereafter the mean weight of the thymus decreased gradually.

The mean volume of whole thymus in group I, II and III was 17.167 ± 1.014 cc, 22.333 ± 2.275 cc and 3.083 ± 0.455 cc respectively. The mean volume of thymus also recorded maximum in group II, however, it decreases significantly (P<0.01) in age group III. The results of these findings indicated that the volume of thymus increased with age, while during involution volume was also decreases alike thymus weight in postnatal Surti goats.

The average mean values of the relative weight in group I, II and III was 0.399 ± 0.092 %, 0.200 ± 0.031 % and 0.015 ± 0.002 % respectively. The weight of thymus as a percentage of body weight decreased significantly from the age group I to III. Bevandic and Arnautovic (1966) reported that the average weigh % ratio of thymus was 0.1% of the body weight at the age between 7 days up to 7.5 months in sheep. Radmehr et al. (1997) also reported that the ratio of thymus to body weight decreases with advancement of age in sheep from 5 months to 8 years of age. Furthermore, Cunningham et al. (2001) observed that the weight of thymus as a percentage of body weight was 0.5% in neonatal lambs, which was much greater than in adult sheep (0.05 % body weight). These observations were in line with present work.

The in the present study the correlation coefficient between age and thymus weight was 0.537, 0.019 and -0.601 in group I, II and III respectively. The age and weight of the thymus showed positive correlation in the postnatal Surti goats in age group I and II, however, negative correlation was observed in group III. Similar observations were reported by Ramayya et al. (2008) in postnatal buffalo calves with age.

In the present study the mean values of various parts of thymus were recorded in different age groups and summarized in table I. The weight and thickness of thoracic part of thymus showed significant (P<0.01) decrease in group III as compared to group II (Table 1). There was significant (P<0.05) increase in the length of cervico-thoracic isthmus from age group I to II, however, in group III increase was not significant (Table 1). The length, width and thickness of the caudal cervical part (Body) decreased significantly in group III as compared to group II (Table 1). The mean weight of whole cervical part was increased significantly from age group I to II (Table 1). There was significant increase in the length of right and left limbs of cervical part of thymus from age group I to II (Table 1). Data of mean values of both limbs showed that the right limb of cervical thymus was longer than the left limb. Contrary to this Sarma et al. (2005) mentioned that the left side of the organ was more developed than right side in pig.

CONCLUSION

From overview of results of present study it is concluded that in postnatal Surti goats regression of thymus usually starts when animal reaches sexual maturity approximately after nine months of age. The cranial parts of cervical thymus disappeared first followed by caudal part, however, remnant of thoracic part persisted in cranial mediastinum even at the age of 48 months in postnatal Surti goats. Moreover, possibility of individual variation regarding prepubertal regression of thymus is still there. Statistical results of present study indicated that after birth along with the increase in age of postnatal Surti goats, various parameters of thymus viz., length, width, thickness, volume as well as weight were also increased gradually up to puberty but due to involution all these parameters decreased significantly in the later part of life in Surti goats.

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REFERENCES

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