

Study on the developmental trend of vertebral column in pre - and postnatal life in sheep (*Ovis aries*)

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The study was conducted on fetuses in 3 , 4 and 5 months of gestation, newly born lambs up to one month age and adult Iranian sheep of Mehraban breed up to 4 years old. All the 5 groups contained 6 animals in each group. The trend of variations in the total length of vertebral column by aging as well as the trend of regional and segmental developmental changes were observed. The total length of vertebral column was 202.8 ± 16.19 mm in 3 month fetus, 294 ± 22.89 mm in 4 month fetus, 405.2 ± 37.28 mm in 5 months fetus, 566.3 ± 30.61 mm in newly born lamb and 1054 ± 87.27 mm in adult sheep. The length of thoracic (T) vertebral column was maximum in the animals of all age groups followed by cervical (C), lumbar (L), coccygeal (Co) and sacral (S) ones, except in 5 months fetus where the length of coccygeal vertebral column was longer than that of the lumbar region. These results further indicated that in the cervical region, C2 vertebra was the longest and C1 the shortest in all the age groups. In thoracic region, T₁ was longest in 3 and 4 months fetuses, whereas in rest of the animals T₁₃ was longest. The shortest vertebrae in this region were T₇ , T₈ , T₅ and T₆ in 3 , 4 and 5 months fetuses, respectively, and T₇ in newly born lamb and adult sheep. In lumbar region L6 vertebra was longest in most of the age groups except in adult sheep where L₅ was longest. In addition to L₆ , L₄ and L₅ were also long in 3 months fetus. However, the shortest vertebra was L₁ in all stages. In sacral region, S₁ vertebra was longest in all age groups, whereas S₄ was shortest except in adult sheep where S₃ was shortest.

Key words : developmental trend, vertebral column, pre - and postnatal life, sheep.

Early investigations on the relative regional length of the vertebral column by Ballantyne (1892) and Bardeen (1905) showed that in young human embryos the cervical region was relatively longer than that of the lumbar and as growth proceeded there was a constant proportional increase in the length of the lumbar as compared with the cervical. BARDEEN (1905) reported that during the second and third month of gestation, in human fetus, the length of the cervical

region was about 60 % that of the thoracic and the length of the lumbar region was at first less than 40% that of thoracic, but later increased to 50% whilst the length of the sacral region varied from 33% to 42.5% of thoracic. These findings were later supported by Bagnall et al (1979). They extended their studies on the individual vertebral unit to show the proportional length of the vertebral segments in different regions of the human vertebral column. The differential growth of the regions of the vertebral column was studied by Muller and O'Rahilly (1986). They reported that the percentages of the total column occupied by the various regions vary from one stage to another.

The potential value of the vertebral column was used as an indicator of fetal maturity by Stockland and Marks (1961) and the measurement of the lumbar spine by Fagerberg and Roonemaa (1959). However, no accurate information about the pre and postnatal development of the vertebral column is available for the correct assessment of such abnormalities as spina bifida, scoliosis and lordosis. This study was therefore undertaken to show the trend of development changed in the vertebral column during pre and postnatal life at total, regional and vertebral segmental levels of the vertebral column in sheep.

Materials and Methods

A total of 30 Iranian sheep of Mehraban breed of either sex were assigned to 5 groups of 6 animals. The groups were of fetuses of 3,4 and 5 months gestation, newly born lambs up to one month of age and adult sheep up to 4 years old. The fetuses were obtained fresh at slaughter, selected and aged according to method of Evans and Sack (1973). The lambs were procured from the age recorded herd and the adult sheep were those used for teaching purpose in the class and embalmed by the method of Hildebrand (1968). The euthanized lambs and all selected fetuses were skinned, eviscerated, the axial skeleton were separated and kept submerged in 10% buffered formaline while they were in a natural anatomical position.

To show the differential growth of vertebral column on the basis of various regions and in each region on the basis of different

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vertebral segments and also to show the trend of these changes according to the aging of animals, in each animal the total, regional and segmental length of vertebral were measured. The length of each vertebral segment was determined by pin pointing the middle of ventral periphery of intervertebral discs, using the calliper and ruler. The data were statistically analysed, using one way of analysis variance test and Duncan's multiple range procedure.

Results

The observations in the developmental trend of vertebral column revealed that the mean total length of vertebral column was 202.80 ± 16.19 mm in 3 months fetus, 294.20 ± 22.89 mm in 4 months fetus, 405.20 ± 37.28 mm in 5 months fetus, 566.30 ± 30.61 mm in newly born lamb and 1054.00 ± 87.27 mm in adult sheep. The trend of these changes were shown in figure 1. The mean values of the regional length of vertebral column in mm as well as the percentage of the regional length were as follows :

3 months fetus

Cervical (C) - *50.17 ± 10.04 (24.73%), Thoracic (T)- 67.50 ± 7.76 (33.28%), Lumbar (L) - *40.33 ± 4.21 (19.88%) , Sacral (S)-20.75 ± 1.78 (10.23%), coccygeal (Co)-*24.08 ± 0.63 (11.87%)

4 months fetus

C-*68.42 ± 4.75 (23.26%) , T - 91.17 ± 4.02 (30.99%), L- *55.08 ± 2.76 (18.72%), S- 26.25 ± 1.66 (8.92%), co

-*53.25 ± 0.71 (18.10%)

5 months fetus

C -*91.67 ± 5.16 (22.63%), T-*125.00 ± 7.60 (30.86%) , L-*74.83 ± 4.55 (18.47%), S - 36.25 ± 2.89 (8.95%), Co - *77.30 ± 0.57 (19.08%)

newly born lamb

C - *135.50 ± 10.40 (23.93%) , T-*183.50 ± 18.60 (32.40%) , L -*108.83 ± 10.30 (19.22%), S - *52.50 ± 7.70 (9.27%) , co - *86.00 ± 10.01 (15.19%)

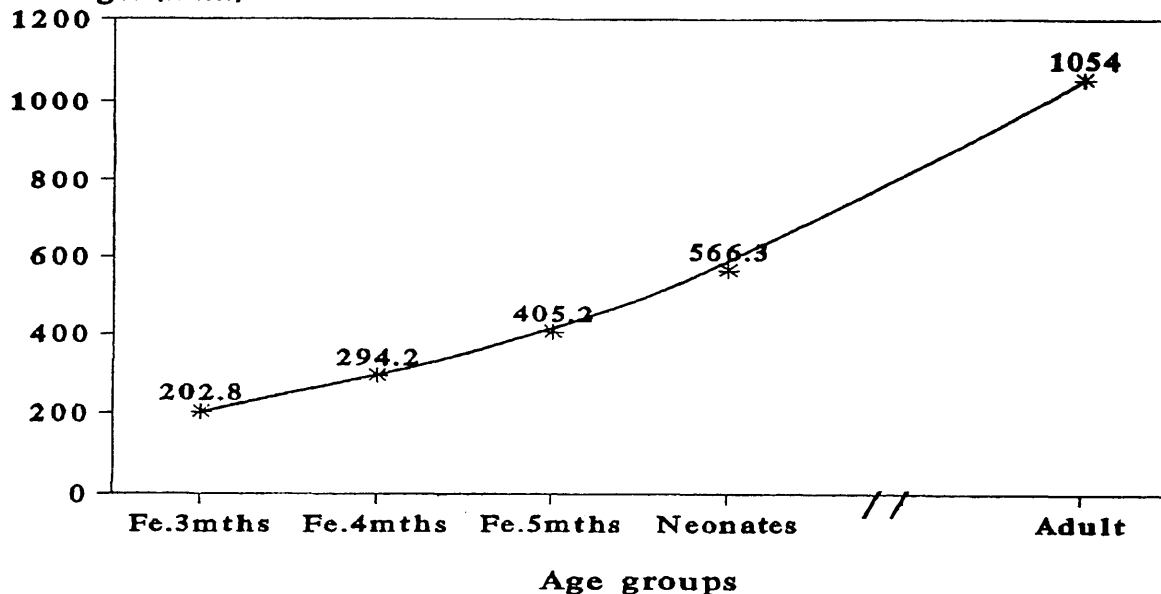
adult sheep

C- *269.33 ± 7.52 (25.55%) , T-*320.92 ± 10.13 (30.45%) , L-*195.50 ± 8.41 (18.55%) , S -*90.00 ± 4.60 (8.54%), Co-*178.30 ± 0.73 (16.92%)

*- significant of P ≤ 0.01 level.

These results indicated that the length of thoracic vertebral column was maximum in the animals of all age groups followed by cervical, lumbar, coccygeal and sacral ones except in 5 month fetus where the length of coccygeal vertebral column was longer than that of the lumbar region. The trend of regional changes according to different ages were shown in figure 2.

FIG.1. Variations in the length of vertebral column in different age groups of sheep.
Mean length(mm.)



The mean length of vertebral segments from C₁ to S₄ were shown in Table 1, and the trend of the segmental changes according to age wereshown in figure 3. According to this Table the longest (Lo) and the shortest (Sh) vertebrae of each region in different ages and their values in mm were as follows :

3 months fetus

Lo / C₂ - 9.67±1.90; T₁ - 5.83±1.30; L₄, L₅, L₆ - 7.00±0.70 ; S₁ - 6.25±0.75 Sh / C₁ - 5.67±0.81; T₇-T₈ - 4.92±0.80; L₁ - 6.25±0.83 ; S₄ - 4.80±0.44

4 months fetus

Lo / C₂ - 13.5±1.04 ; T₁ - 7.92±0.80 ; L₆ - 9.83±0.40 ; S₁ - 8.25±0.41 sh / C₁ - C₇ - 8.00±0.63 ; T₅ - T₆ - 6.58±0.49 ; L₁ - 8.67±0.81 ; S₄ - 5.50±0.54

5 months fetus

Lo / C₂ - 18.17±2.04 ; T₁₃ - 10.92±0.80 ; L₆ - 13.67±1.08 ; S₁ - 12.08±0.80 Sh / C₁ - 10.67±1.20 ; T₆ - 8.83±0.75 ; L₁ - 11.42±0.80 ; S₄ - 7.33±1.03

newly born lamb

Lo / C₂ - 28.17±0.98 ; T₁₃ - 16.33±1.50 ; L₅, L₆ - 18.83±1.80 ; S₁ - 17.33±1.90 Sh / C₁ - 14.50±1.90 ; T₇ - 12.92±1.20 ; L₁ - 16.83±1.40 ; S₄ - 11.20±1.90

Adult sheep

Lo / C₂ - 53.08±1.60 ; T₁₃ - 29.00±1.50 ; L₅ - 33.67±1.30 ; S₁ - 26.83±2.40 Sh / C₁ - 27.00±2.00 ; T₇ - 23.17±0.75 ; L₁ - 32.00±1.20 ; S₃ - 21.00±1.80.

FIG.2.Variation in the length of various regions of vertebral column in different age groups of sheep.

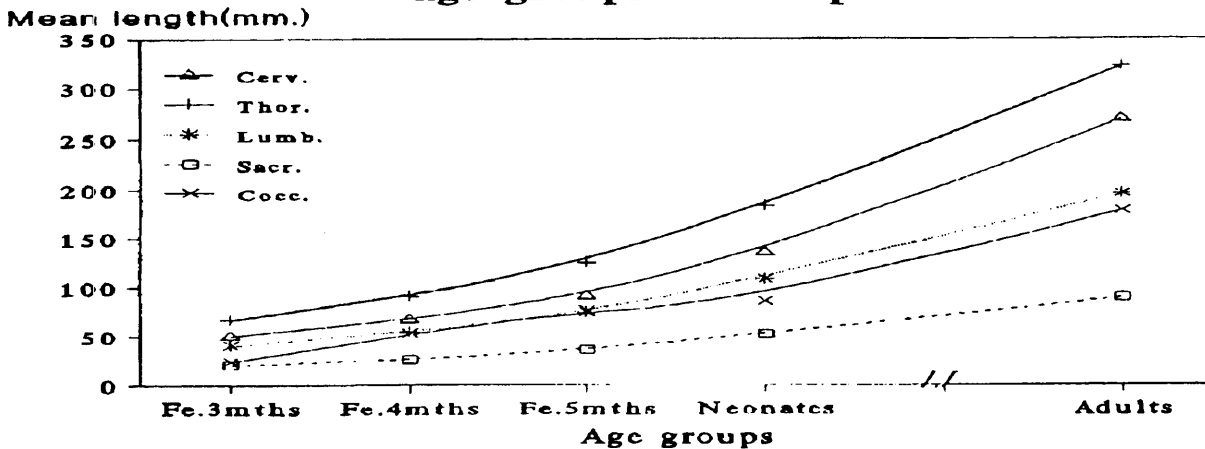
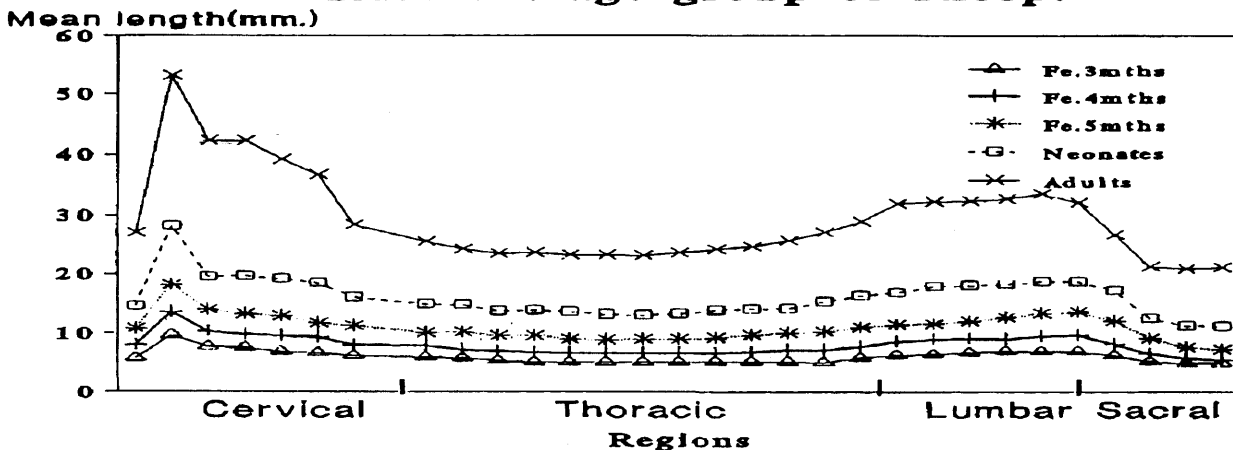


FIG.3.Length of vertebra in different age group of sheep.



The results revealed that in the cervical region, C₂ vertebra was the longest and C₁ shortest in all the age groups. In thoracic region, T₁ was longest in 3 and 4 months fetuses whereas in the rest of the animals T₁₃ was longest. The shortest vertebrae in this region were T₇ and T₈; T₅ and T₆ in 3, 4 and 5 month fetuses respectively and T₇ in newly born lamb and adult sheep. In lumbar region, L₆ vertebra was longest in most of the age groups except in adult sheep where L₅ was longest. In addition to L₆, L₄ and L₅ were also long in 3 month fetus. However, the shortest vertebra was L₁ in all ages. In sacral region, S₁ vertebra was longest in all age groups whereas S₄ was shortest except in adult sheep where S₃ was shortest vertebra.

Discussion

The developmental trend of vertebral column in pre - and postnatal life of Iranian sheep of Mehraban breed showed that the

mean of total, regional and vertebral segmental length and the percentages of regional length varied from one stage to another either interregionally or between the related regions in different ages. In fetuses of 3, 4, 5 month age and newly born lamb, the growth rate of vertebral column from one stage to another was at the constant rate of 1.4 times, whereas between newly born lambs and adult sheep it increased to 1.9 times. In the animals of all age groups, the thoracic region was the longest and the sacral region was the shortest. These observations were in agreement with the earlier reports of Bagnall et al. (1979). in human beings and Getty (1975) in cattle and horses, While in the albino mouse at the age of one day, the thoracic region was longest and the coccygeal region was the shortest one and at 120 days, also the thoracic region was longest and the cervical and coccygeal regions were equally the shortest regions (Sakla, 1969).

Table.1. Length of vertebral segments in sheep. ($\bar{X} \pm Sd$).

segment	LENGTH (mm)				
	3 months fetus	4 months fetus	5 months fetus	newly born lamb	adult
C ₁	5.67±0.81*	8.00±0.63*	10.67±1.20*	14.50±1.90*	27.00±2.00*
C ₂	9.67±1.90*	13.50±1.04*	18.17±2.04*	28.17±0.98*	53.08±1.60*
C ₃	7.67±1.90	10.25±0.98	13.92±0.91*	19.50±2.10*	42.33±1.80*
C ₄	7.50±1.70	9.75±0.75	13.17±0.98*	19.67±2.60*	42.33±1.30*
C ₅	6.83±1.40*	9.58±0.91*	12.83±0.98*	19.17±1.40*	39.25±1.40*
C ₆	6.67±1.20	9.33±1.03	11.67±1.20	18.50±1.50*	36.83±2.90*
C ₇	6.17±1.10	8.00±0.63	11.25±1.40	16.00±1.80*	28.50±3.70*
T ₁	5.83±1.30	7.92±0.80	10.08±0.91	14.83±2.20*	25.50±2.70*
T ₂	5.67±0.81	7.17±0.40	10.17±0.40*	14.75±2.30*	24.17±0.98*
T ₃	5.17±0.40*	7.00±0.00*	9.50±0.54*	13.67±1.50*	23.50±0.83*
T ₄	5.00±0.63*	6.75±0.41*	9.50±0.54*	13.83±1.30*	23.67±0.81*
T ₅	5.00±0.63*	6.58±0.49*	9.00±0.89*	13.50±1.70*	23.25±0.61*
T ₆	5.00±0.63*	6.58±0.49*	8.83±0.75*	13.08±1.20*	23.25±0.61*
T ₇	4.92±0.80*	6.67±0.51*	9.00±0.89*	12.92±1.20*	23.17±0.75*
T ₈	4.92±0.80*	6.67±0.51*	8.92±0.80*	13.25±1.30*	23.67±1.30*
T ₉	5.08±0.66*	6.67±0.51*	9.17±0.75*	13.83±1.30*	24.17±1.10*
T ₁₀	5.08±0.66*	6.83±0.40*	9.67±0.81*	14.00±1.09*	24.67±1.80*
T ₁₁	5.08±0.66*	7.25±0.41*	10.00±0.63*	14.17±1.10*	25.75±1.60*
T ₁₂	5.00±0.63*	7.25±0.41*	10.25±0.75*	15.33±1.20*	27.17±1.30*
T ₁₃	5.75±0.61*	7.83±0.75*	10.92±0.80*	16.33±1.50*	29.00±1.50*
L ₁	6.25±0.88*	8.67±0.81*	11.42±0.80*	16.83±1.40*	32.00±1.20*
L ₂	6.43±0.81*	8.92±0.66*	11.59±0.91*	17.92±1.70*	32.33±1.20*
L ₃	6.75±0.75*	9.08±0.49*	12.00±0.63*	18.08±1.80*	32.50±1.80*
L ₄	7.00±0.70*	9.08±0.49*	12.75±0.75*	18.33±1.50*	32.83±1.60*
L ₅	7.00±0.70*	9.50±0.54*	13.42±1.10*	18.83±1.80*	33.67±1.30*
L ₆	7.00±0.70*	9.83±0.40*	13.67±1.08*	18.83±2.20*	32.17±2.40*
S ₁	6.25±0.75	8.25±0.41	12.08±0.80*	17.33±1.90*	26.83±2.40*
S ₂	5.17±0.75	6.67±0.81	9.17±0.40*	12.66±1.30*	21.40±1.90*
S ₃	4.83±0.75	5.83±0.75	7.67±0.81	11.33±2.06*	21.00±1.80*
S ₄	4.80±0.44	5.50±0.54	7.33±1.03	11.20±1.90*	21.33±1.50*

* = significant, $p \leq 0.01$



The present results revealed that in 3 and 4 months fetuses, the thoracic region was the longest followed by cervical, lumbar, coccygeal and sacral, whereas in 5 month fetus although the thoracic region was still the longest but followed by cervical, coccygeal , lumbar and sacral regions, respectively, which apparently showed that in the last month of gestation in sheep the coccygeal region grew faster than that of the lumbar region. Conversely, in humans, after 8 th week of gestation, lumbar region grow faster than cervical region (Bagnall et al., 1979).

Comparison of the length of the regions of vertebral column in sheep showed that the length of all regions were significantly increased ($p \leq 0.01$) according to the age of the animals except the sacral region which during 3 , 4 and 5 months of gestation did not show a significant increase in length, however, in human also during the prenatal life, the sacral region did not increase in length (Muller and O'rahilly, 1986).

The comparative percentage of the length of related regions in pre - and postnatal life of sheep showed that from 3 to 5 months of gestation, the length of cervical region was gradually decreased from 24.73% in 3 months fetus to 22.6% in 5 months fetus. During this period the length of thoracic region was also decreased from 33.28% in 3 months fetus to 30.86% in 5 months fetus and the length of the lumbar region from 19.88% in 3 months fetus decreased to 18.74% in 5 month fetus and the sacral region from 10.23% in 3 months fetus decreased to 8.9% in 5 month fetus, while the length of coccygeal region increased from 11.87% in 3 months fetus to 19.08% in 5 months fetus. In 5 month fetus and newly born lambs up to one month age, it was observed that although the length of the thoracic, cervical, Lumbar and sacral regions increased but the length of coccygeal region decreased from 19.08% in 5 months fetus to 15.19% in new born lambs. In newly born lambs and adult sheep, the length of the cervical region increased from 23.93% in new born lambs to 25.55% whereas that of thoracic region during this period decreased from 32.40% to 30.45% . The length of the lumbar and sacral regions were slightly decreased but that of coccygeal region it was increased from 15.19% in newly born lambs to 16.92% in adult sheep.

Since each region of vertebral column contained different numbers of vertebrae, it was interesting to know the trend of developmental growth of vertebral units (vertebra plus disc) in all regions. The mean length of each individual vertebra from C₁ to S₄ was studied and the longest and shortest vertebra of each region was pin pointed. The present findings indicate that in sheep, the mean length of cervical and lumbar vertebrae were more than those of other regions, While in humans in the second half of pregnancy the lumbar vertebrae were longer than the vertebrae of the other regions and this situation continued even after birth (Bardeen, 1904; 1908 - 9; Bagnall et. al. 1979).

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مطالعه روند رشد ستون مهره‌ای در زندگی قبل و بعد از نوزادی درگوسفند

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این مطالعه روی جنین‌های ۳، ۴، ۵ ماهه بزه‌های نوزاد و گوسفندان بالغ نژاد مهربان بعمل آمده است. هر گروه سنی شامل ۶ حیوان بود. تغییرات رشد تکاملی براساس طول کلی، ناحیه‌ای و سگمنتی (قطعه‌ای) مورد بررسی قرار گرفته است. میانگین طول کلی ستون مهره‌ای در جنین سه ماهه، $16/19 \pm 202/80$ میلیمتر، در جنین چهار ماهه $22/89 \pm 294/00$ میلیمتر در جنین پنج ماهه $37/28 \pm 405/20$ میلیمتر، در بزه نوزاد $30/61 \pm 566/30$ میلیمتر و در گوسفند بالغ $87/27 \pm 1054/00$ میلیمتر می‌باشد. در تمام گروه‌های سنی طول ناحیه سینه‌ای بیشترین مقدار بوده و دنبال آن نواحی گردنی، کمری، دمی و خاجی قرار داشته است. بااستثنای جنین پنج ماهه که طول ناحیه دمی بیشتر از ناحیه کمری بوده است. در ناحیه گردنی تمام گروه‌های سنی C_2 طولیترین مهره و C_1 کوتاهترین می‌باشد. در ناحیه سینه‌ای، در جنین‌های سه و چهار ماهه T_1 طولیترین مهره می‌باشد در حالیکه در بقیه گروه‌های سنی T_{13} طولیترین مهره است. در تمام گروه‌های سنی مهره‌های $T_6 - T_8$ کوتاهترین می‌باشند. در ناحیه کمری L_6 طولیترین مهره بوده بااستثنای گوسفند بالغ که L_5 طولیترین است. در حالیکه در تمام گروه‌های سنی L_1 کوتاهترین مهره این ناحیه است. در ناحیه خارجی تمام گروه‌های سنی S_1 طولیترین مهره و S_4 کوتاهترین می‌باشد. بااستثنای گوسفند بالغ که S_3 کوتاهترین مهره ناحیه خاجی می‌باشد.

