HISTOMORPHOMETRIC STUDIES ON THE PRENATAL DEVELOPMENT OF THE TESTIS CORDS OF ONE-HUMPED CAMEL (CAMELUS DROMEDARIUS)

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ABSTRACT

The present investigation was carried out to demonstrate the process of prenatal development of the testis cords by histological and morphometric methods. Fifty-six male camel embryos and fetuses with CVRL ranging from (2.2 cm-105 cm) were used in this study. The indifferent gonads appeared in the form of two small bilateral cellular masses bulged slightly into the celomic cavity medial to the mesonephros at 2.2 cm CVRL. Their parenchyma didn't show any pattern of cord like arrangement. Few ill organized testis cords were observed for the first time within the newly differentiated testis at 4 cm CVRL camel embryos. They were formed from one or more gonocytes surrounded by some supporting cells and in turn wrabbed by thin interrupted basement membrane demarcating them from the surrounding interstitium. With advancement of age the testis cords appeared more organized and increased in their numbers and length. At 14 cm CVRL the supporting cells appeared numerous and confined to the periphery of the cords, meanwhile the gonocytes were few in number and located either within the center of the cords or among the peripherally seated supporting cells. At 23 cm CVRL the male sex cords showed more convolutions that were indicated by high number of cords per microscopic field and many of them were wrabbed by single layer of peritubular myoid cells. The connection between the testis cords and the rete testis occurred at 32 cm CVRL. At 39 cm CVRL the testis cords were clearly differentiated into outer convoluted part and inner straight part which passed toward the centrally located rete testis. Concentrically arranged fibrous tissue was seen surrounding the testis cords at 78 cm CVRL. At 105 cm CVRL camel fetuses the testis cords appeared underwent progressive convolutions that result in their appearance in different shapes. All the cords were still uncanalized and surrounded by clear PAS positive basement membrane. The diameter of the testis cords as well as the number of both types of their contained cells increased with age.

INTRODUCTION

The organogenesis of the gonads is unique in that both the testis and ovary are derived from an initially bipotential tissue, the genital ridge. The seminefrous tubules of the adult testis are derived from embryonic precursors, the testis cords. The testis cords contain the

Sertoli cells, which support the development of the primordial germ cells. The latter are the progenitors of the spermatogonial cells. Although the process of testicular development was found to be of good interest to many investigators, the histogenesis of the camel testis is still in its infancy. The origin of supporting gonadal cells was a matter of controversy through out many decades. Some authors stated that they come from cells of mesonephric origin **(Zamboni and Upadhyay, 1982 in sheep and Karl and Capel, 1995 in mouse).** Others postulated that the celomic epithelium is the main source for the supporting cells of the testis (Karl and Capel, 1998 in mouse and Gaber, 2005 in camel).

Moreover, Martineau; Nordqvist; Tilmann; **Lovell-Badge and Capel (1997) and Cool; Carmona; Szucsik, and Capel (2008)** investigated the origin of the peritubular myoid cells in mouse embryos.

Only few reports on the prenatal development of the testis cords could be traced in the available literatures where: **Nada (1986); Abou-Basha (1989) and Gaber (2005)** studied the process of their histogenesis. The aim of the current study was to reveal the process of prenatal development of the testis cords by histological and morphometric methods.

MATERIAL AND METHODS

The present study was conducted on 56 male camel embryos and fetuses (2.2 cm-105 cm CVRL) that were obtained from Cairo, Zagazig and Belbis abattoirs. All the specimens were fixed in 10% neutral buffered formalin and/or Bouin's solution. The specimens up to 8 cm CVRL were taken as a whole and in those over 8 cm the testis was removed carefully. All the specimens were processed by the routine method and tissue sections of 5-7 um thickness were prepared and stained according to **Bancroft and Stevens (1990)**. The stained slides were examined under the light microscope. Thirty clearly cut testis cords were selected and average diameter of the testis cords as well as the average number of the gonocytes and supporting cells per each cord were examined and recorded. All measurements were made by using an eyepiece micrometer. The counting of cells was done manually under light microscopic examination and confirmed by using image-J analysis software (a Java-based image processing program that was developed at the National Institutes of Health, Maryland, USA).

RESULTS

The indifferent gonads of 2.2 cm CVRL camel embryos appeared in the form of two small bilateral cellular masses that bulged slightly into the celomic cavity medial to the mesonephros and lateral to the dorsal mesentery of the gut (fig. 1). They were attached to the mesonephros by a broad mesogonadium. The parenchyma of the indifferent gonads didn't show any pattern of cord like arrangement. At 4 cm CVRL camel embryos the testis was formed mainly from two types of cells; large cells represented the migrated primordial germ cells or the gonocytes and relatively smaller cells the primitive gonadal cells or the supporting cells or the pre-Sertoli cells. These two types of cells were mostly found separated from each others, but some cells from both types might aggregated to each others forming cords, the male sex cords or the testis cords (fig. 2).

At 8 cm CVRL camel embryos both the number of the testicular cords and the cellularity of the testis were markedly increased. The average diameter of the testis cord was 25 um. Each cord formed from 8-10 supporting cells surrounding 1-2 gonocytes. Although many testis cords appeared more organized and some of them were surrounded by a single layer of elongated cells (fig. 3), some parts of the testis still devoid of any cord like structures. Many interstitial endocrine cells (of Leydig) were encountered within the spaces between the testis cords. They appeared small in size and contained spherical-shaped nuclei with one or more distinct nucleoli. At 14 cm CVRL camel embryos the testis cords increased in length. The supporting cells appeared numerous and confined to the periphery of the cords, meanwhile the gonocytes were few in number and located either within the center of the cords or among the peripherally seated supporting cells. The interstitium between the cords contained an increased number of interstitial endocrine cells as well as many small blood vessels (fig. 4). At 15 cm CVRL camel embryos the testis was separated from the primitive epididymes by a space which represented the primordia of the testicular bursa. The testis cords increased in both their number especially at the peripheral parts of the testis and length and some of them had curled peripheral ends (fig. 5).

At 23 cm CVRL camel embryos the sex cords showed more convolutions that were indicated by high number of cords per microscopic field. The supporting cells increased in number (about 25-27 cells/cross-sectioned cord). The gonocytes were still few in number (about 2-3 cells/cross-sectioned cord) and they were seen mostly within the center of the testis cords. A single layer of peritubular myoid cells were seen wrabbing the basal laminae of many testis cords. The interstitial endocrine cells increased in count and filled most of the spaces between the testis cords (fig. 6).

At 32 cm CVRL camel embryos the testis cords still separated from each others by large amount of interstitial endocrine cells. Some cords were seen for the first time connected to the straight tubules of the rete testis (fig. 7). At 36 cm CVRL camel embryos the testis cords varied in both shape and length. Their average diameter was 53.5 um. The number of testis cords anastomosed with the rete testis increased than at the 32 cm CVRL camel embryos. Some supporting cells were located within the center of the testis cords inbetween the gonocytes (fig. 8). Some testis cords appeared in the form of a closed ring surrounding a core of interstitial tissue (fig. 9 & 10). These ring-shaped testis cords were seen without any connection to the tubules of the rete testis. At 39 cm CVRL camel embryos the testis cords were clearly differentiated into outer convoluted part near the tunica albuginea and inner straight part which passed toward the centrally located rete testis. Many cords were seen connected to the tubules of the rete testis by long canalized straight tubules (fig. 11).

At 52 cm CVRL camel embryos the testis cords showed a more pronounced convolutions toward the periphery of the testis, meanwhile their central parts remain straight and passed inwards to join the tubules of the rete testis. Some testis cords appeared with curled

peripheral ends and connected to long straight tubules, others appeared straight and anastomosed with relatively short straight tubules (fig. 12). By the same age, a testis cords was detected within the testicular mediastinum among the tubules of rete testis (fig. 13). At 78 cm CVRL camel embryos the testis cords appeared surrounded by a coat of concentrically arranged fibrous tissue (fig. 14). The interstitium appeared in the form of narrow spaces between the highly convoluted cords.

At 105 cm CVRL camel embryos the testis cords appeared in different shapes. They might resemble the letters n, u, v or s. Some cords contained a complete circular layer of central supporting cells within their lumina that gave them the appearance of number 8 or the shape of a door key (fig. 15). Regarding the canalization of the testis cords, all of the cords were solid and still uncanalized. They surrounded by very clear basal laminae and contained the two types of previously mentioned cells: the gonocytes and the supporting cells. The gonocytes appeared with spherical shaped nuclei that appeared with heterogenous sizes (some nuclei appeared hypertrophied and large in size, others appeared small). They still fewer in number than the supporting cells (only 6.6 cells/ cross sectioned cord) and restricted to the center of the cords, although few cells appeared smaller in size and pushed toward the periphery of the cords in between the supporting cells, that might be regarded as a sign of their transformation into fetal spermatogonia (fig. 16).

The number of gonocytes within many testis cords was steadily increased. That might be attributed to their divisions. The divisions affecting the gonocytes were mostly amitotic as no chromosomal changes had been detected within their nuclei. Although the approximate sequential steps of these amitotic divisions could not be determined, it might be summarized in the following points: an increase in the size of both the cytoplasm and the nucleus of cells, followed by division of the nucleus and cytoplasm equally forming two smaller daughter cells. This assumption might be supported by the presence of binucleated gonocytes within the lumina of many testis cords (fig. 16 & 17). Also some large multinucleated gonocytes were seen within the lumina of the testis cords (fig. 18). The presence of these multinucleated cells might be explained to be due successive divisions within the nuclear material which were accompanied by failure of the cytoplasm to divide. On the other hand, some gonocytes were seen underwent retrogressive changes (fig. 17). These changes ranged from pykonsis of the nucleus to complete lyses of the cell. The rate of occurrence of these retrogressive changes appeared to be lower than those of the amitotic divisions which might explain why the count of gonocytes increased steadily with age.

The supporting cells appeared with oval shaped nuclei. They were oriented at the periphery of the cords perpendicular to their basal laminae forming a peripheral nuclear ring (about 38 cells/cross sectioned cord). They showed no stratification and only formed one layer. The basal laminae of the testis cords were surrounded by a complete layer of peritubular myoid cells and in turn wrabbed by many layers of concentrically arranged fibro-

blasts and small-sized blood vessels.

Regarding the reaction to PAS staining, both of the interstitial endocrine cells as well as the cells within the testis cords were negatively reacted. The interstitium especially in the vicinity of the testis cords showed a mild positive reaction (fig. 19). On the contrary strong PAS positive reaction was seen within the mediastinum testis and the reaction of the testicular capsule appeared moderate.

DISCUSSION

In the present work the testis cords were observed for the first time at 4 cm CVR camel embryos length towards the mesorchium. They formed from one or more gonocyte surrounded by some supporting cells and in turn wrabbed by thin interrupted basement membrane demarcating them from the surrounding interstitium. Similar finding were observed in camel embryos of 4cm CVRL by **Nada (1986)**, 5cm CVRL by **Ali (1994)** and 7.5cm CVRL by **Gaber (2005)**. The first appearance of the testicular cords varied according to species, they were firstly observed in horse at 30 days and in bull at 41 days (**Gier and Marion, 1970**), by the 58th day of fetal age in buffalo **(El-Rafey, 1990)** and at 19 days old rabbit embryos **(El-Okaha, 1993)**.

In the current investigation, with advancement of age, the testis cords appeared more organized and increased in their numbers per microscopic field. They increased in length being more convoluted peripherally and attained straight course toward the center of the testis. Some cords appeared with looped peripheral ends and others may join each others before joining the centrally located rete testis. Similar results were given by the aforementioned authors.

The present work revealed that, shortly after sexual differentiation (approximately at 8 cm CVRL camel embryos) the testis cords were surrounded by a single layer of elongated cells that differentiated from the pericordal mesenchyme. These cells formed the myoid elements of the testis cords and seemed to be directory cells responsible for testis cord formation. Similar findings were reported by Nosseur, Ammar, **Bareedy and Basha (1988)** in goat, **El-Rafey (1990)** in buffalo, **El-Okaha (1993)** in rabbit, **Gaber (2005)** in camel and **Parchami et al. (2008)** in sheep. **Hullinger and Wensing (1985)** described the peritubular cells as to be myoid cells responsible for the contractility of the seminefrous tubules.

Nada (1986) in camel recorded the presence of some testicular cords among the rete testis. The same finding was observed in the present work at 52 and 58cm CVRL camel embryos. **Gaber (2005)** also denoted the presence of some testicular cords within the testicular mediastinum in 30, 37 and 45 cm CVRL camel fetuses.

During the prenatal period of development in camel the testis cords appeared in different shapes. According to the plan of cutting and their degree of branching and convolutions, they might appear circular, cylindrical, H-shape and S-shape. Some testis cords appeared ring-shaped. These ring-shaped cords were surrounded externally by abasement membrane demarcating them from the surrounding interstitium and internally by an-

other basement membrane that limited the cords from a core of interstitial cells. Also these ring-shaped testis cords were seen without any connection to the tubules of the rete testis. These ring shaped cords were a characteristic feature of the developing camel's testis as their prevalence had not been reported in any other species. In camel the presence of ring-shaped testis cords were noted by **Nada (1986) and Gaber (2005)**.

In the present investigation the lumen of the testis cords remained solid during the whole prenatal life. This simulates the findings of **Oier and Marion (1970)** in cattle, **Abdel-Maksoud (2005)** in bovines, **Gaber (2005)** in camel and **Parchami et al. (2008)** in sheep. On the contrary, the testicular cords acquired a lumen in 5.5 months bull fetuses **(Santamarina and Reece, 1957)**, in 8 - 9 months camel fetuses **(Fahmy and George, 1967)** and in full term camel fetuses **(Abou-Basha, 1989 and Ali, 1994)**.

Throughout the entire period of prenatal development the testis cords were containing two types of cells; the gonocytes which were large in size, few in number and mostly seen within the center of the cords as well as the supporting cells that were smaller in size, high in number and located at the periphery of the cords. Similar findings were observed by the previously mentioned authors. In the present study some indifferent supporting cells were pushed into the center of the cords. The presence of central supporting cells was observed by **Nada (1986) and Abou-Basha (1989)** in camel.

In the current investigation the diameter of the testis cords as well as the number of both types of its contained cells increased with age. These findings were in accordance with those of **Gaber (2005)** in camel and **Parchami et al. (2008) & Dehkordi et al. (2008)** in sheep.

The present study revealed that one type of gonocytes could be seen within the testis cords as all the gonocytes showed no remarkable morphological differences within their nuclei or their cytoplasm. This finding was consistent with that of **Abdel-Maksoud (2005)** in bovines and **Parchami et al. (2008)** in sheep, but not in agree with those of **Schrag (1983)** which stated that the bovine germ cells showed two different types (light and dark) that possessed different cellular functional states. **Nossour, et al. (1988)** in 7.1 cm CVRL goat embryos noted that in addition to the supporting cells the testis cords contained another two types of cells; large cells with darkly stained spherical nuclei and clear cytoplasm, termed the basal stem cells and large cells with large spherical vesicular nuclei and highly acidophilic cytoplasm, named the gonocytes and the latter two types were present toward the center of the cords.

Nada (1986) stated that during the development of the testis of camel, the gonocytes within the testicular cords showed morphological changeg that led either to their maturation and formation of fetal spermatogonia or degenration to reduce the number of maturing gonocytes. The maturing gonocytes appeared smaller in size and aligned themselves along the basal lamina of the testis cords. **Gaber (2005)** in the same species mentioned that at late stage of pregnancy, some of the gonocytes are located in-between the somatic

cells but didn't reach the basement membrane. In the present work some gonocytes of smaller size and condensed chromatin were seen displaced near the basament membrane of the testis cords during late stage of gestation. Moreover some degenerative changes were seen affecting the gonocytes. These degenerative changes were observed only during the late period of development and ranged from pykosis of the nuclei to lysis of the cells. On the other hand, **El-Okaha (1993)** in rabbit embryos noted that the degenerative changes affecting the gonocytes within the testicular cords were evident from the time of testicular differentiation.

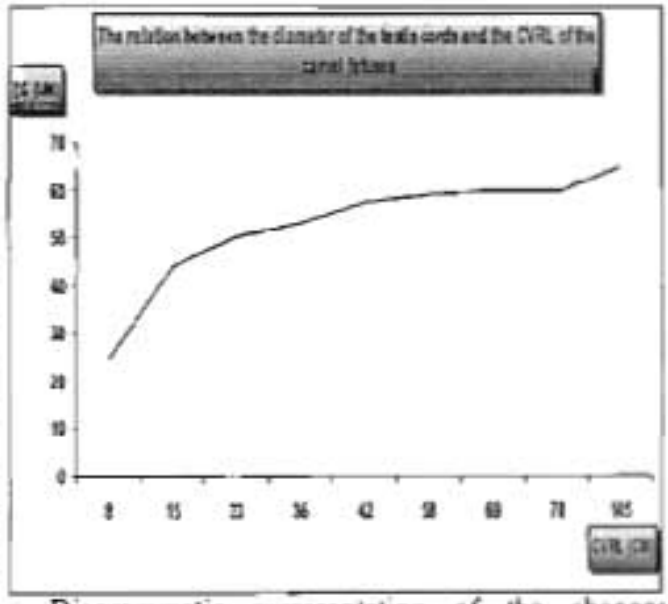
In order to compensate the reduction in their numbers caused by degenration, the gonocytes underwent cellular division. These divisions might be mitotic especially during early period of gestation (**El-Rafey, 1990** in buffalo and **El-Okaha, 1993** in rabbit). During late stage of gestation the divisions were mostly amitotic which supported by the presence of binucleated or mulinucleated cells within the lumina of many testis cords which were recorded by the present study and by the aforementioned authors in addition to **Nada (1986)** and **Abou-Basha (1989)** in camel.

During late period of gestation in camel the majority of the testis cords appeared surrounded by clear and continuous P.A.S positive basement membrane and in turn by more than one layer of concentrically arranged peritubular cells. This agreed with the results obtained by **Nada (1986)** and **Gaber (2005)** in camel as well as **El-Okaha (1993)** in rabbit.

Conclusion: From the abovementioned discussion of the testicular cords, it is indicated that the testicular cords of camel fetuses which represent the exocrine part of the testis are poorly developed in comparison with the other animals as in full term fetuses the cords still solid and the gonocytes do not reach the basement membrane. Therefore, the testicular cords are expected to continue their development postnatally.

Table (1): The relation between the diameter of the testis cords (TC) and the CVRL of the camel fetuses.

CVRL	TC
8	25
15	44.5
23	50.6
36	53.5
42	57.5
58	59
69	60
78	60
105	65

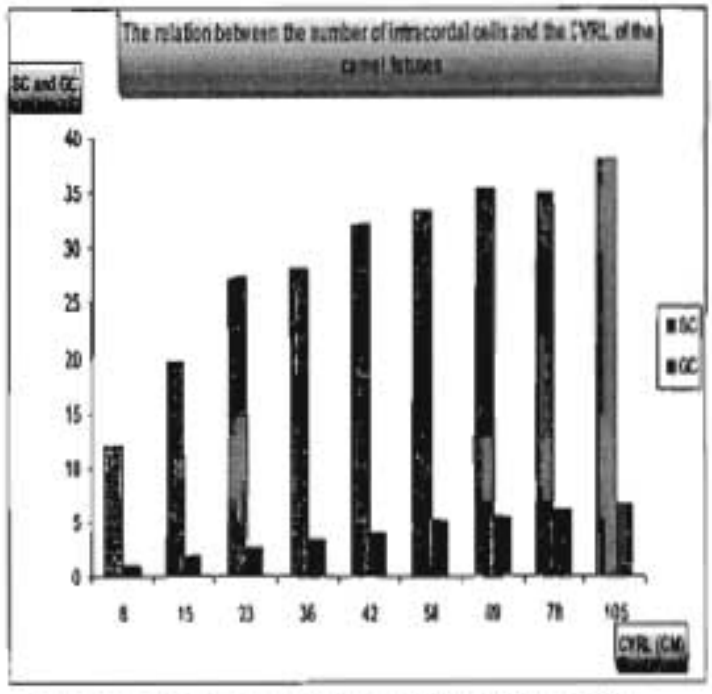


- Diagrammatic representation of the changes occurred in the diameter of the testis cords. The maximum diameter was at 105 cm CVRL.

Table (2): The relation between the number of the intracordal cells and the CVRL of the camel fetuses.

CVRL	SC	GC
8	12	1
15	19.8	1.9
23	27.4	2.6
36	28.3	3.4
42	32.1	4
58	33.5	5.1
69	35.3	5.6
78	35	6
105	38	6.6

- SC: the supporting cells
- GC: the gonocytes



Diagrammatic representation of the number of the intracordal cells. The number of the cells within the testis cords increased with age.

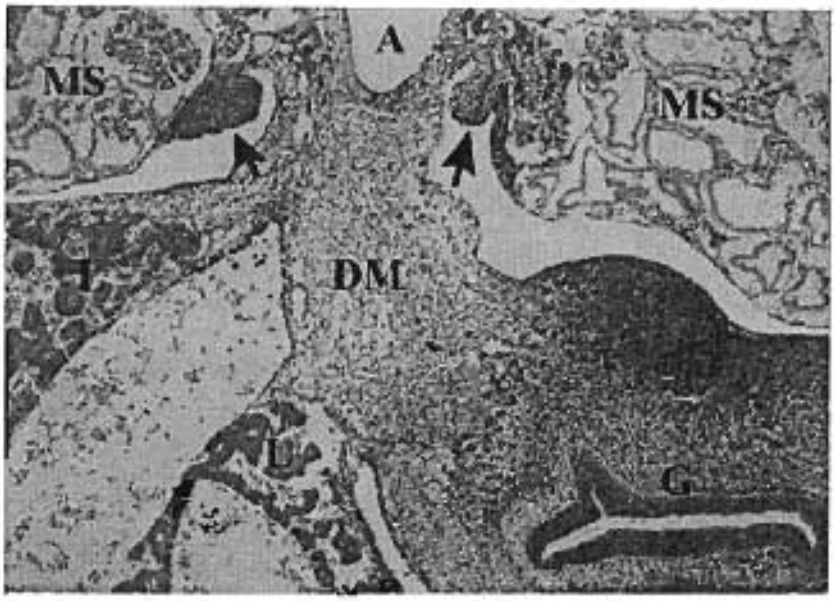


Fig. (1): Photomicrograph of cross section in 2.2 cm CVRL camel embryo showing: the genital ridges appeared in the form of two small bilateral masses (arrows) medial to the mesonephros (MS) and lateral to the dorsal mesentery of the gut (DM). The aorta (A) and the liver (L) could also be seen. H&E stain, X4.

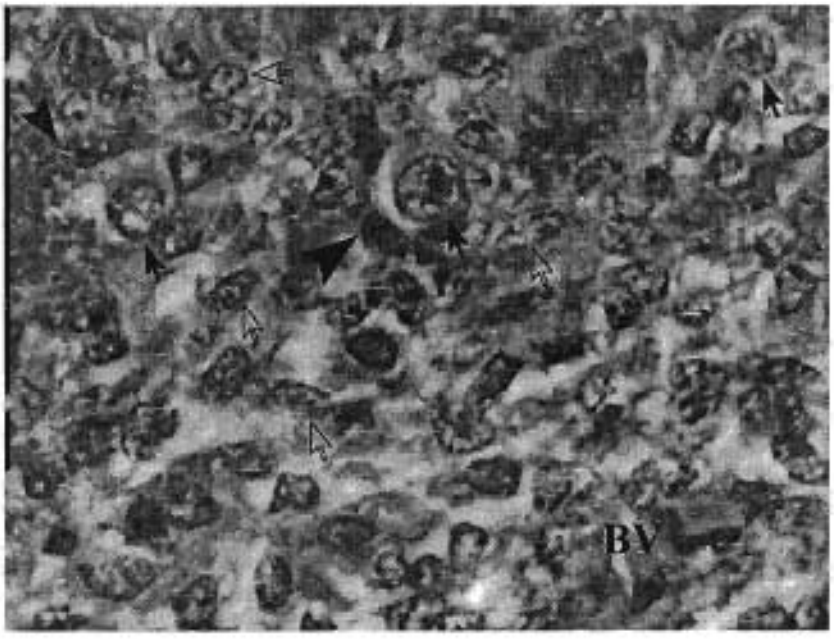


Fig. (2): Photomicrograph of the testis of 4 cm CVRL camel embryo showing: the gonocytes (solid arrows) and the supporting cells (empty arrows). Some cells from the both type might aggregate and form cords, the testis cords (arrow heads). H&E stain, X100.

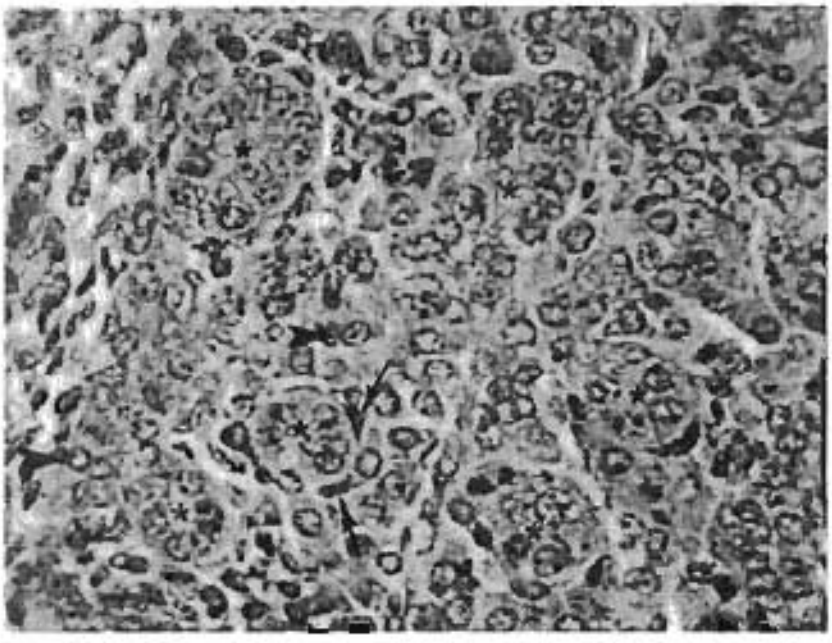


Fig. (3): Photomicrograph of the testis of 8 cm CVRL camel embryo showing: some testis cords (asterisks) were surrounded by single layer of elongated cells (arrows). The interstitial endocrine cells could be detected within the interstitium between the cords (arrow heads). H&E stain, X40.

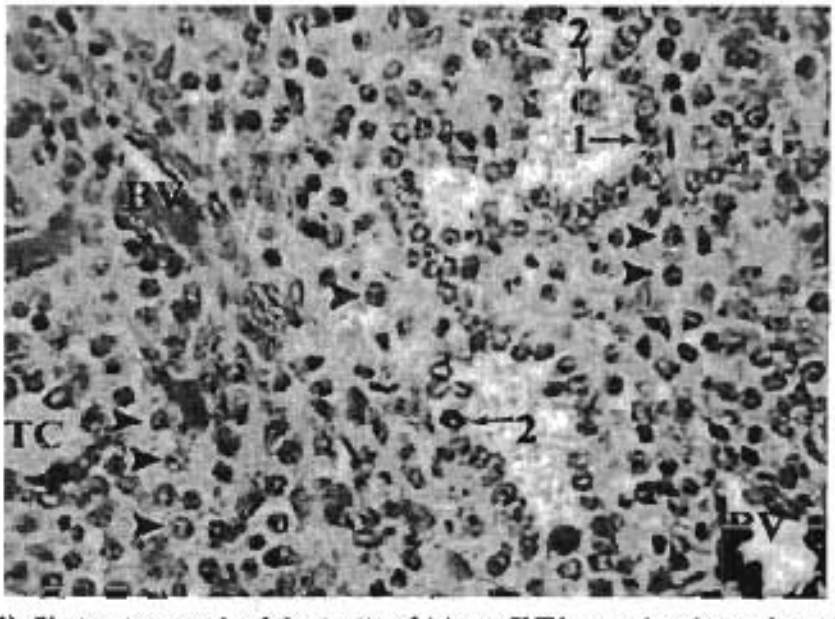


Fig. (4): Photomicrograph of the testis of 14 cm CVRL camel embryo showing: the testis cords increased in length and contained two types of cells; the supporting cells (1) which appeared numerous and confined to the periphery of the cords and the gonocytes (2) that appeared few in number and located either within the center of the cords or among the peripherally seated supporting cells. The interstitium between the cords contained an increased number of interstitial endocrine cells (arrow heads) as well as many blood vessels (BV). H&E., stain X40.

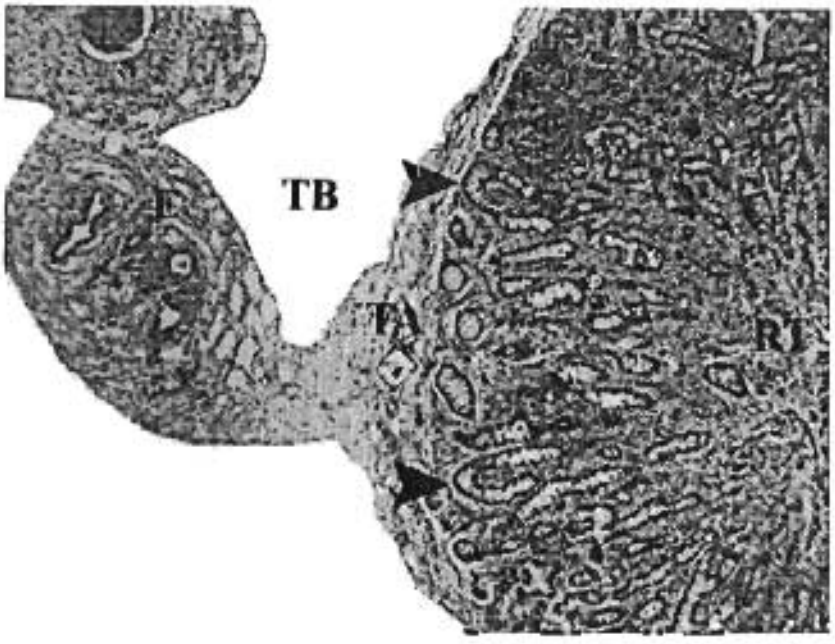


Fig. (5): Photomicrograph of the testis of 15 cm CVRL camel embryo showing: the testis separated from the primitive epididymes (E) by the testicular bursa (TB). The testis cords increased in number and some of them had curled peripheral ends (arrow heads). H&E., stain X4.

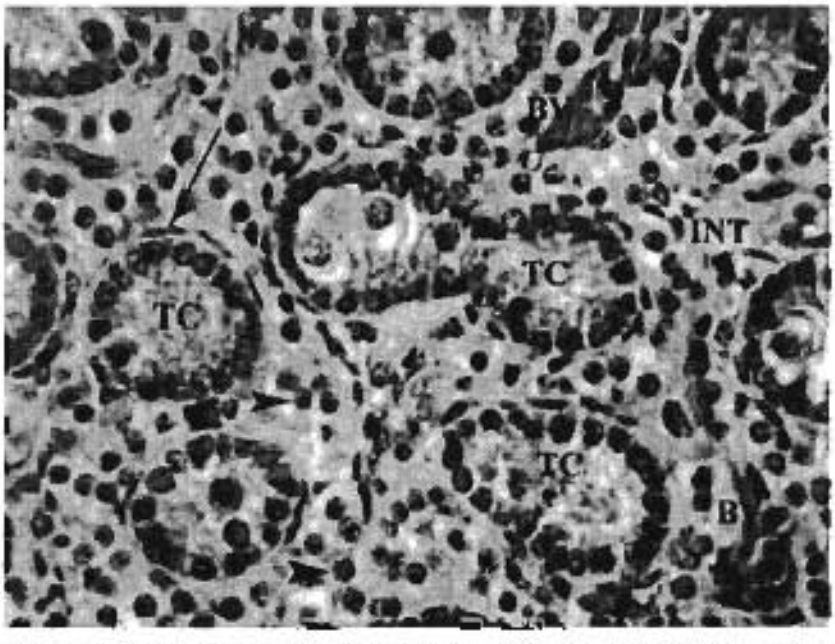


Fig. (6): Photomicrograph of the testis of 23 cm CVRL camel embryo showing: the testis cords were clearly organized and surrounded by a single layer of peritubular myoid cells (arrow). The interstitial endocrine cells increased in number and filled whole the spaces between the cords (arrow heads). H&E., stain X40.

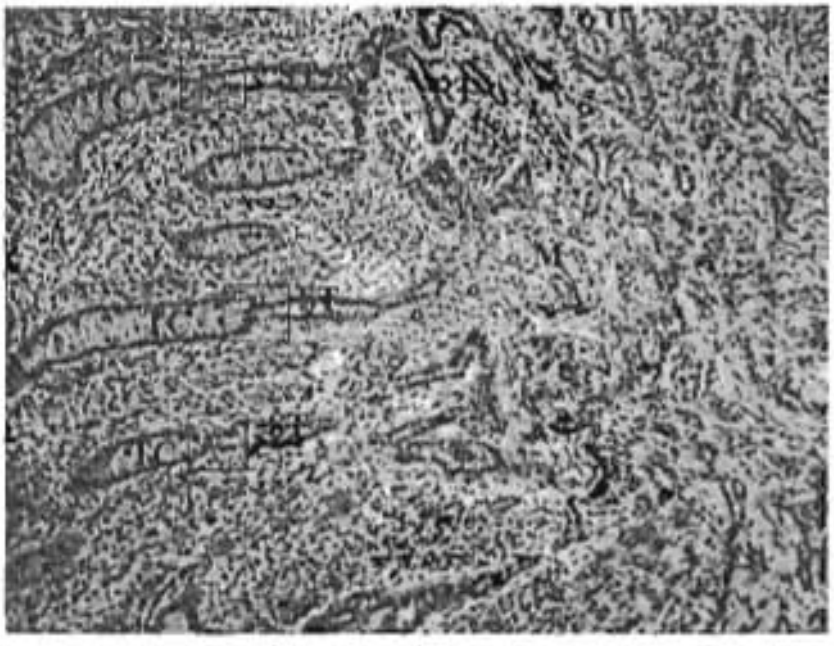


Fig. (7): Photomicrograph of the testis of 32 cm CVRL camel embryo showing: the connection between the testis cords (TC) and the straight tubules (ST) had been established (squares). H&E., stain X10.

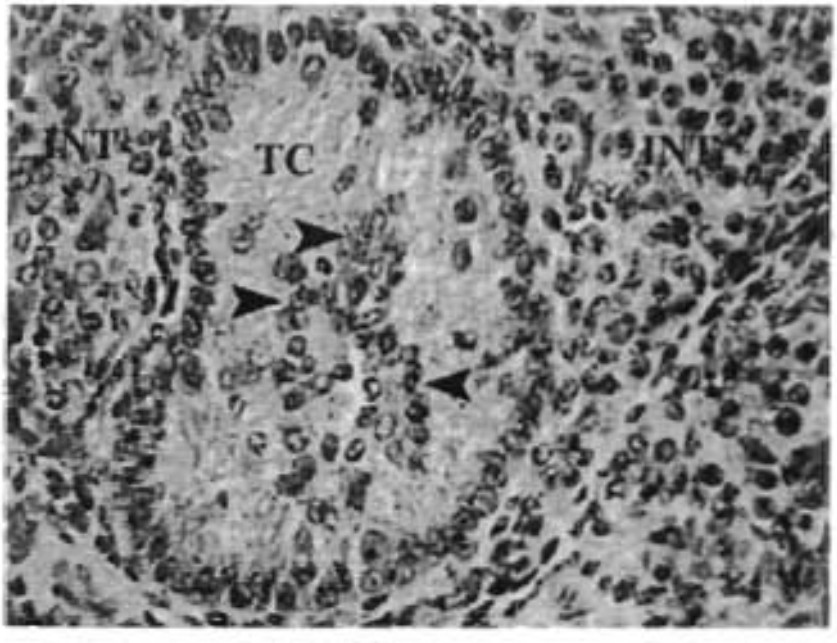


Fig. (8): Photomicrograph of the testis of 36 cm CVRL camel embryo showing: some supporting cells testis appeared within the center of the testis cords (arrow heads). The interstitium (INT) increased in its cellular and vascular contents. H&E., stain X 40.

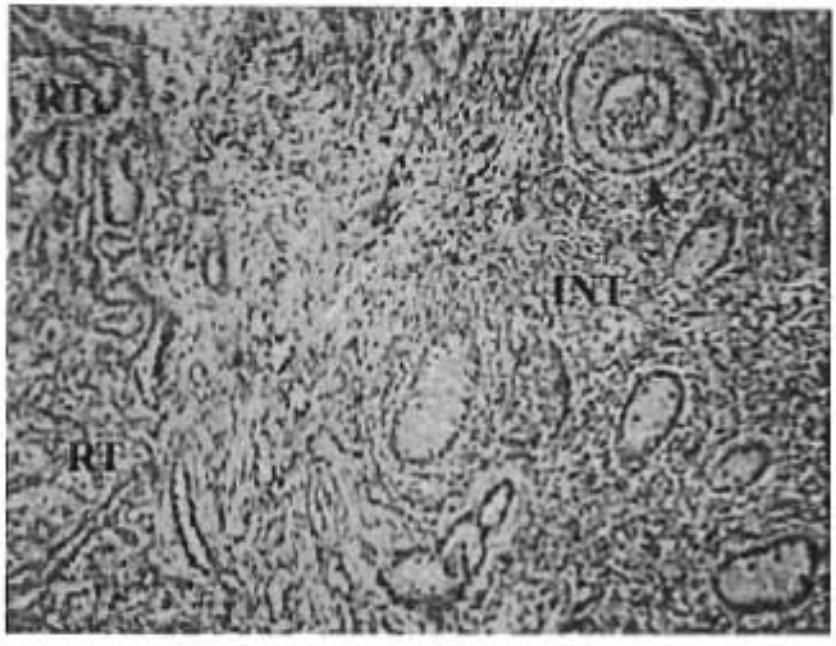


Fig. (9) : Photomicrograph of the testis of 36 cm CVRL camel embryo showing: some testis cords (TC) appeared in the form of closed ring (arrow). This ring-shaped cord was not connected to the tubules of the rete testis (RT). H&E., stain X40.

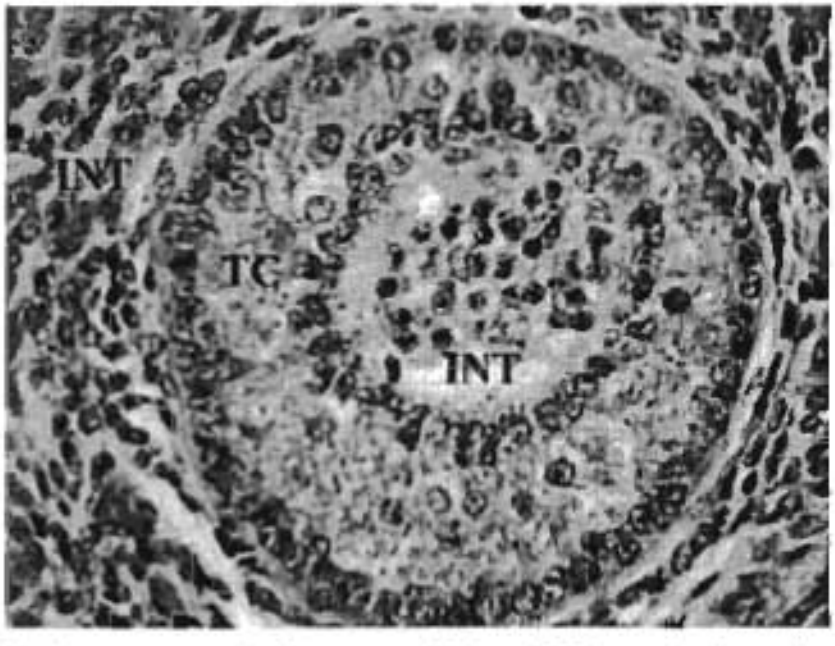


Fig. (10): Photomicrograph of the testis of 36 cm CVRL camel embryo showing: a ring shaped testis cord enclosing a core of interstitial endocrine cells (INT). H&E., stain X40.

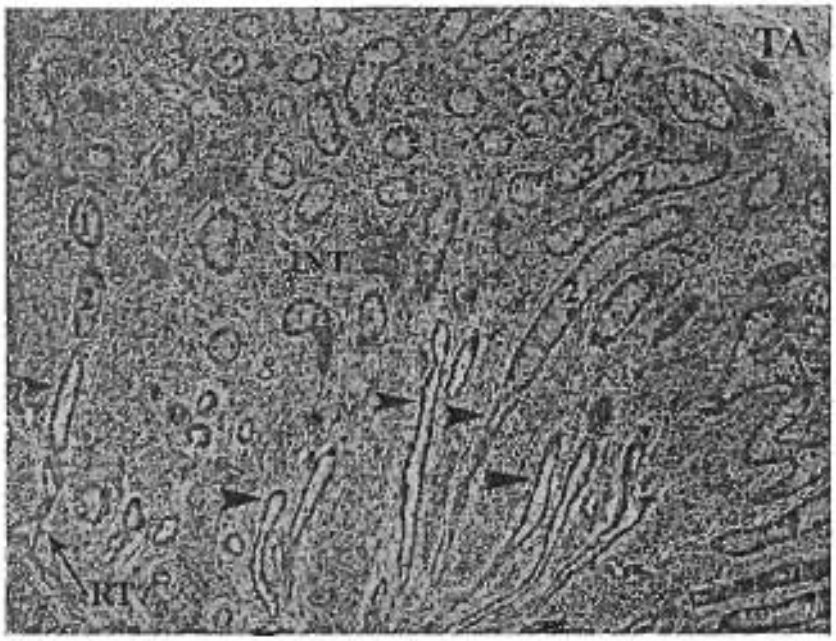


Fig. (11) : Photomicrograph of the testis of 39 cm CVRL camel embryo showing the testis cords were differentiated into; an outer convoluted part (1) near the tunica albuginea (TA) and an inner straight part (2). The cords were separated from each others by highly vascularized interstitium (INT). The straight tubules increased markedly in length (arrows). H&E. stain, X10.

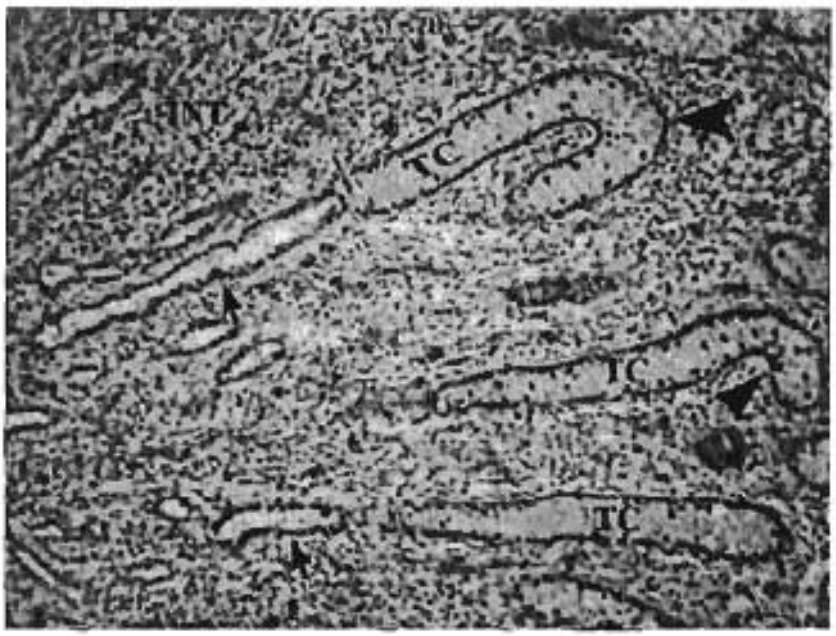


Fig. (12): Photomicrograph of the testis of 52 cm CVRL camel embryo showing; some testis cords appeared with curled peripheral ends (arrow heads). The straight tubules appeared with variable lengths (arrows). H&E. stain, X10.

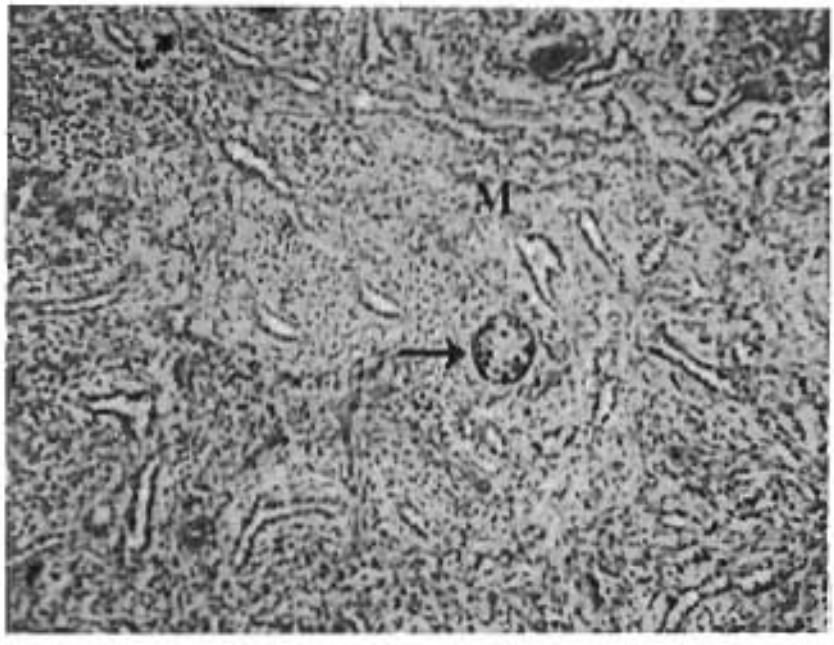


Fig. (13) : Photomicrograph of the testis of 52 cm CVRL camel embryo showing; a testis cords was detected wthin the testicular mediastinum (M) among the tubules of rete testis (arrow). H&E. stain. X10.

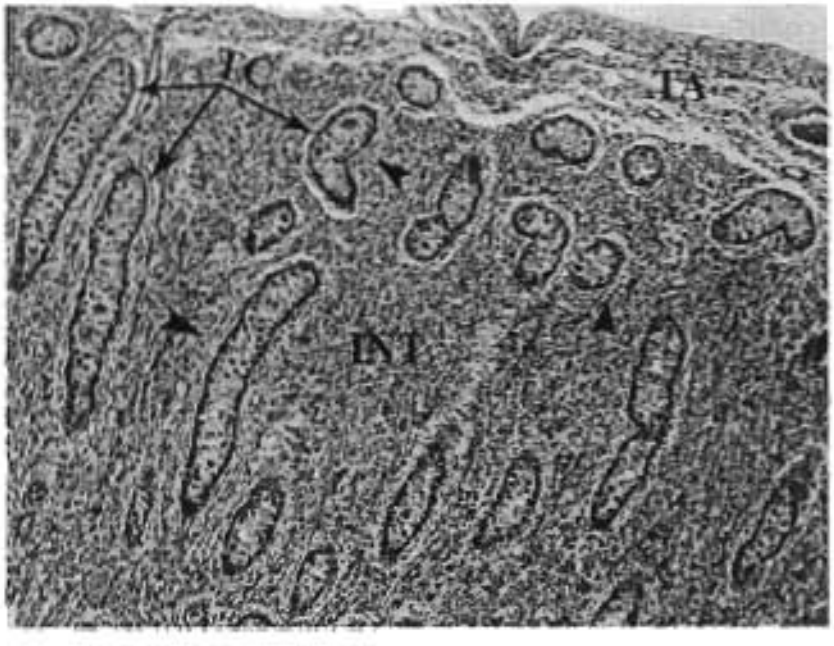


Fig. (14): Photomicrograph of the testis of 78 cm CVRL camel embryo showing; the testis cords (TC) surrounded by a coat fibroua tissue (arrow heads). The interstitial cells (INT) formed clusters in-between the cords. H&E. stain. X10.

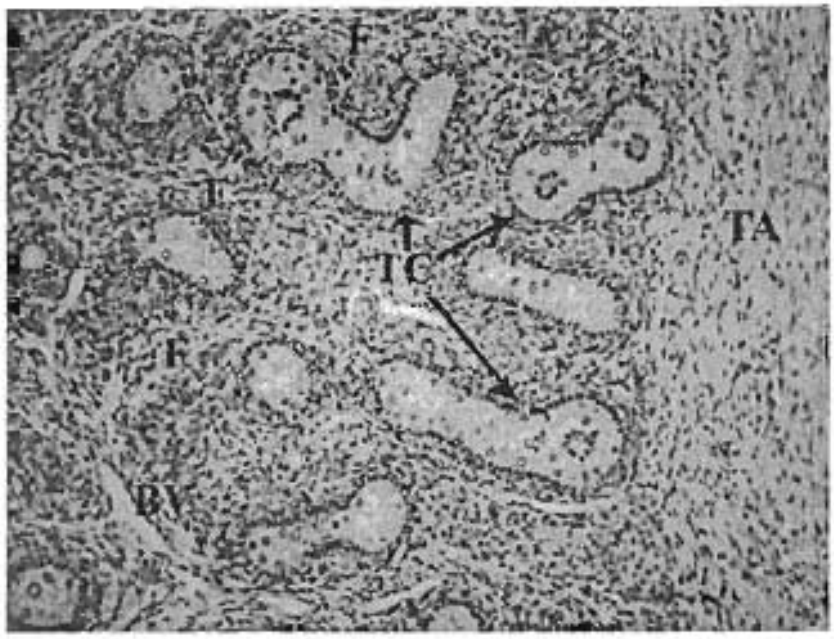


Fig. (15) : Photomicrograph of the testis of 105 cm CVRL camel embryo showing: the testis cords appeared with different shapes (arrows). The interstitium between the cords formed from high amount of fibrous tissue (F) and many blood vessels (BV). H&E stain, X10.

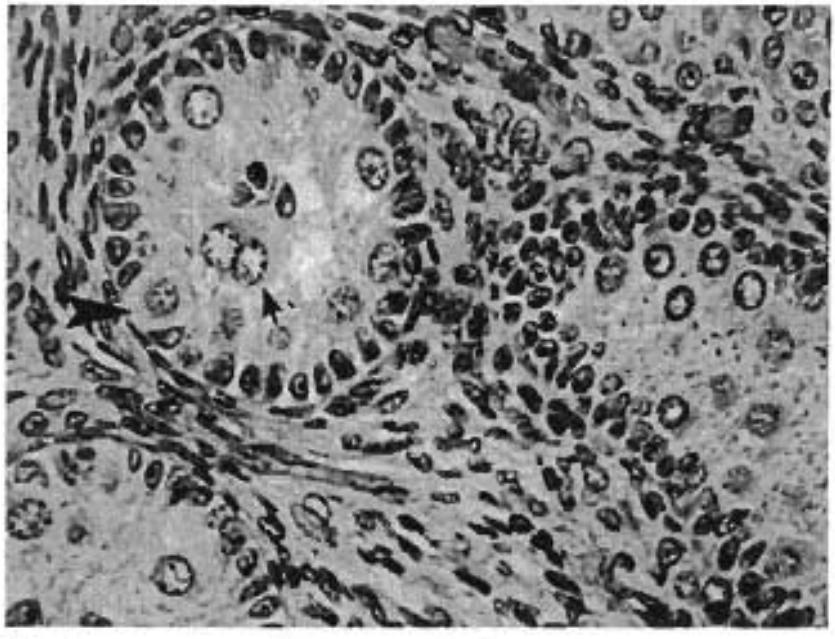


Fig. (16): Photomicrograph of the testis of 105 cm CVRL camel embryo showing: binucleated gonocyte (arrow) and peripherally seated pre-spermatogonium (arrow head). H&E stain, X 40.

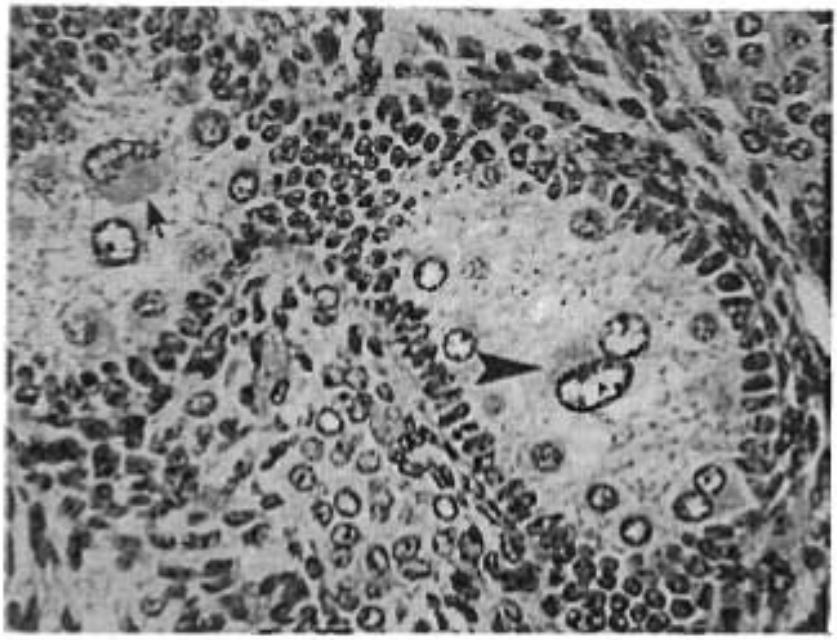


Fig. (17) : Photomicrograph of the testis of 105 cm CVRL camel embryo showing: binucleated gonocyte (arrow head) and gonocyte in early stage of degeneration (arrow). H&E stain. X40.

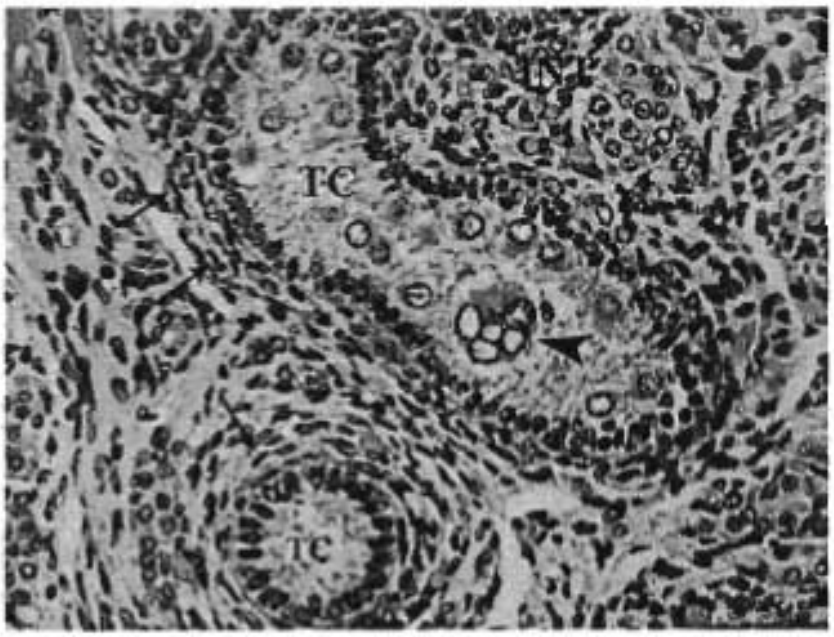


Fig. (18): Photomicrograph of the testis of 105 cm CVRL camel embryo showing: multinucleated gonocyte within the lumen of the testis cord (TC). The cord was surrounded by about 2-3 layers of concentrically arranged fibroblasts (arrows). H&E stain. X 40.

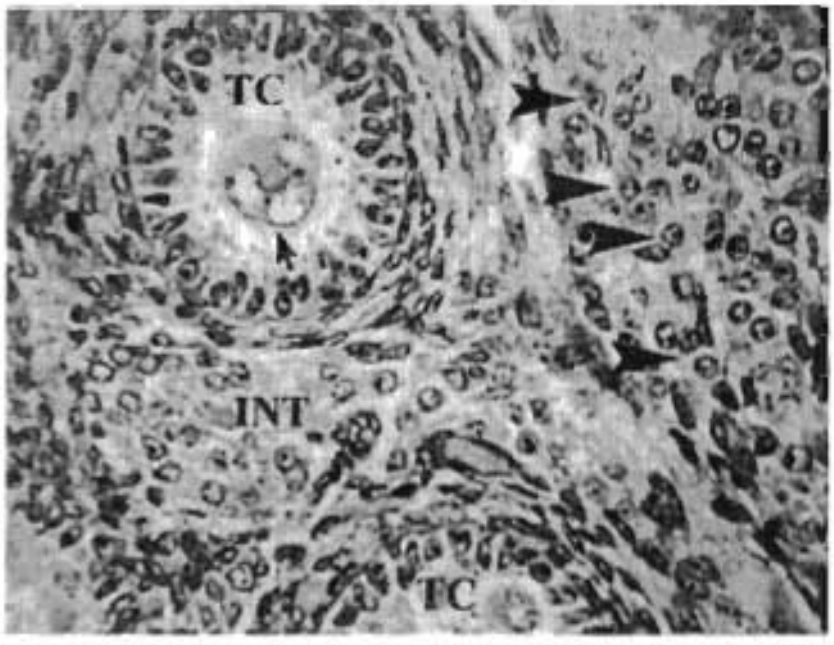


Fig. (19) : Photomicrograph of the testis of 105 cm CVRL camel embryo showing: mild positive reaction within the basement membrane of the testis cords as well as in the testicular interstitium. The cells of the testis cords (TC) and the interstitial endocrine cells (arrow heads) reacted negatively. Tri-nucleated gonocyte appeared within the lumen of the testis cord (arrow). PAS stain. X40.

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الملخص العربى

دراسات هستومورفومترية على نمو الأحبال المنوية فى الجمل وحيد السنام قبل الولادة

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تم إجراء هذه الدراسة علي عدد سته وخمسون جنينا جمليا ذكريا مختلفي الأطوال (2.2 سم - 105م) قيست بمقياس الطول الجبهي القفاري الكفلي. وقد عولجت العينات بالطرق الهستولوجية المعروفة وأظهرت النتائج أن الغدة الجنسية الغير متميزة تتواجد علي الجانب الأنسي للكلية الوسطي عند الطول الجنيني 2.2 سم. شوهدت الأحبال المنوية للمرة الأولي عند الطول الجنيني 4 سم. بينما عند الطول الجنيني 14 سم ظهرت الأحبال المنوية أكثر تميزا مع زيادة في كلا من عددها وطولها. رتبت الخلايا في داخل الحبل المنوي إلي نوعين علي حسب الشكل والعدد والحجم. النوع الأول وهو عبارة عن خلايا ال gonocytes أو الخلايا الجنسية وهي خلايا ذات نواة كروية كبيرة الحجم و تتواجد غالبا في وسط الحبل المنوي أما النوع الثاني فتمثلت في ال supporting cells أو الخلايا الداعمة وهي خلايا ذات أنوية بيضاوية الشكل أصغر حجما من أنوية الخلايا الجنسية. إقتصر تواجد هذه الخلايا علي الحواف الداخلية للأحبال المنوية.

عند الطول الجنيني 23 سم شوهدت أعداد كبيرة من الأحبال المنوية في المقطع العرضي الواحد وقد أرجع ذلك إلي زيادة تلافيف تلك الأحبال في هذه الفترة من العمر.بالإضافة إلي ذلك لوحظت طبقة من الخلايا شبه العضلية تحيط عدد كبير من الأحبال المنوية. عند الطول الجنيني 32 سم تواصلت هذه الأحبال المنوية مع قنيات شبكة الخصية. أما عند الطول الجنيني 36 سم فظهرت العديد من الخلايا الداعمة في منتصف الأحبال المنوية كما شوهدت أيضا بعض الأحبال في صورة حلقة مقفلة تحاط داخليا وخارجيا بمجموعات من الخلايا البينية. عند الطول الجنيني 39 سم تميزت الأحبال المنوية إلي جزئين: الأجزاء الخارجية الملاصقة للطبقة البيضاء للخصية ظهر ملتفه .أما الأجزاء الداخلية القريبة من مركز الخصية فظهرت مستقيمة. ظهرت الأحبال المنوية

محاطة بعدة طبقات من الخلايا الليفية عند الطول الجنيني 78سم فصاعدا.

أما عند الطول الجنيني 105 سم فأظهرت النتائج أن الأحبال السرية تظهر بأشكال مختلفة بسبب الزيادة الملحوظة في نسبة تلافيف تلك الأحبال وإعادة ترتيب الخلايا بداخلها. أظهرت النتائج أيضا أن متوسط قطر الحبل السري بالإضافة إلي عدد كلا من الخلايا الجنسية والداعمة يزداد بصورة تدريجية خلال فترة النمو الجنيني. وقد توقشت هذه النتائج مع مثيلاتها في الحيوانات الأخرى وفي الإنسان.