Original Article

Uterine Rat Telocyte Structure and Organization: An Immunohistochemical and Ultrastructural Study

Fatma Al-Zaharaa A. H. Aziz , Eman S. Mahmoud and Rania M. Al Nabawy

Department of Histology, Faculty of Medicine for Girls (Cairo), Al-Azhar, University, Egypt

ABSTRACT

Introduction: Telocytes (TCs) are a kind of interstitial cell found in a variety of organs, including the uterus. They regulate uterine contractions, maintain pregnancy, and prevent premature labour. The purpose of this research was to study the structure, organisation and distribution of telocytes in different uterine layers in adult and senile rats.

Material and Methods: Twenty-four female rats were equally divided into four groups: GI: adult non-pregnant, GII pregnant, GIII postpartum, and GIV senile. The uterine samples from middle one-third of the right horns were processed for light microscopic examination were treated using C-kit stains for immunohistochemical detection of telocytes, and TEM examination. Morphometric and statistical analysis for the data were done.

Results: Telocytes were detected in the endometrium and myometrium of adult non-pregnant uteri as tiny cells with numerous lengthy telopodes. There was a significant increase in endometrial telocytes with a significant decrease in myometrial telocytes in (GII). (GIII) and (GIV) had the largest count of myometrial telocytes.

Conclusion: Telocytes were found in the endometrium and myometrium of the rat uterus. Telocytes serve as a uterine peacekeeper, initiating and coordinating myometrial contraction.

Received: 19 March 2022, **Accepted:** 04 July 2022

Key Words: Electron microscope; Immunohistochemical; rats; telocytes; uterus.

Corresponding Author: Eman S. Mahmoud, MD, Department of Histology, Faculty of Medicine for Girls (Cairo), Al-Azhar University, Egypt, **Tel.**: +20 10 0217 1324, **E-mail:** emansaed.medg@azhar.edu.eg

ISSN: 1110-0559, Vol. 46, No. 3

INTRODUCTION

Telocytes (TCs) are a distinct group of cells identified in 1911 in the mammalian stomach by the pioneering Spanish neurologist and pathologist Santiago Ramón y Cajal. He called them 'interstitial neurons' because to their projections and their locations between nerve terminals and smooth muscle cells[1], independently established that 'interstitial neurons' were not truly neurons and renamed them 'interstitial cells of Cajal' (ICCs)[2].

After establishing that these cells differ from interstitial cells of Cajal (ICC) and all other interstitial cells, their designation was changed to telocytes (TCs) in 2010[3].

Telocytes have been detected in a variety of vertebrates, including humans, mice, rats, guinea pigs, and chickens, and in a variety of organs,[4] including the pancreas,[3] the esophagus[5], the small intestine, and the colon[6]. Telocytes were also found in all of the heart's layers, including the epicardium[3], the endocardium[7], and the myocardium[8]. Telocytes were found throughout the reproductive system, including the prostate[9], testes[10], uterus, myometrium[11], and placenta[12].

The word "telocyte" refers to a cell with lengthy protrusions on[13]. TCs have a triangular or an ovoid somatic body and many (two to five) moniliform cytoplasmic projections (telopodes) with thin segments (podomeres) and dilated parts (podoms). TCs have an oval nucleus and a little amount of cytoplasm containing mitochondria; 5-10% of the cytoplasmic volume; 1-2% of the cytoplasmic volume is endoplasmic reticulum, which may be smooth or rough. Additionally, intermediate filaments, thin filaments, and microtubules exist[14]. Telopodes make interaction with a variety of cell types in their environment, including immune cells, muscle fibres, blood vessels, and epithelial cells[4].

TCs vary from Cajal interstitial cells and other interstitial cells (e.g. fibroblasts, fibrocytes, and fibroblast-like cells) in terms of their expression of cell surface antigens and microRNA profiles[15].

Telocytes operate as a pacemaker, generating the bioelectrical slow wave potential required for smooth muscle contraction[16]. They are involved in the regulation of smooth muscle cells' (SMCs) contractility and excitability[17]. They may participate in the myogenic contractile process that occurs during sperm transit prior to fertilisation, embryo implantation, and delivery[18].

Although the role of uterine TCs is unknown, experimental data suggests that telocytes may operate as modulators of spontaneous uterine contraction. This may be accomplished hormonally, since uterine telocytes express oestrogen and progesterone receptors Numerous studies have suggested that telocytes may operate as sensors for sex hormone levels associated with pregnancy maintenance[11].

 DOI: 10.21608/ejh.2022.128427.1661

Due to the fact that the TCs morphology and number alter in pathological diseases such as pre-eclampsia, endometriosis, and ovarian failure, there is a possibility that they might help to the treatment of such disorders[18].

Telocytes account for around 7% of total cells in non-pregnant myometrial cell culture and approximately 3% of total cells in the myometrium of adult non-pregnant people[3].

The purpose of this research was to determine the structure, organisation, and distribution of telocytes in the uterus of adult and senile female rats.

MATERIALS AND METHODS

Animals

Twenty-four female albino rats were housed in ordinary stainless steel crushed cages (5/cage) at Al-Azhar University's College of Medicine for females. They were maintained under careful care and sanitary conditions of temperature, relative humidity, and a 12-hour light/dark cycle. They were given food pellets from Cairo's Factory of Oil and Soap Company, as well as certain vegetables for vitamins, which were accessible ad libitum along with drinking tap water. For one week, the rats were acclimated to the laboratory setting. They were divided into four groups, each with six rats.

Adult non-pregnant rats weighing 170–190 gm were classified as Group I (GI).

Adult pregnant rats in Group II (GII) on days 16–18 of gestation. They were around three to four months old and weighed between 230 and 270 gm. Female rats were mated overnight (each male rat was mated with 2 females). Vaginal smears were checked daily for finding a vaginal plug and that day was considered as gestational day (GD) one. The average time of delivery was during the morning of day 23.

Group III (GIII): Adult Postpartum rats, on day 3 postpartum. They were about 3-4 months old and weighed 180–200 gm.

Group IV (GIV): Senile group, about 18-24 months old, and weighed from 280-330 gm.

The rats of all groups were sacrificed after being sedated with ether. The abdomens were opened by midline incision, the uteri were dissected and the middle one-third of the right uterine horns (for pregnant rats, the implantation sites of the middle one-third) was removed.

Immunohistochemistry using c-kit (CD117)

The sections were routinely immunohistochemically prepared and incubated overnight at 4 °C with primary antibodies for c-kit (CD117) diluted in 1% bovine serum albumin in phosphate-buffered saline (PBS; pH 7.4) (The primary antibody, the antibody diluent supplied by DAKO corporation laboratories, Carpinteria, CA 93013, USA. They were stored at 2-8˚C). The cells that were positive for the c-kit had brown cytoplasmic deposits and blue nuclei[19]. Positive control: Human tonsil, intestinal tissues, skin, brain, & lung (IHC World- CD117(c-Kit)Antibody staining protocol for immunohistochemistry) (Figure 1).

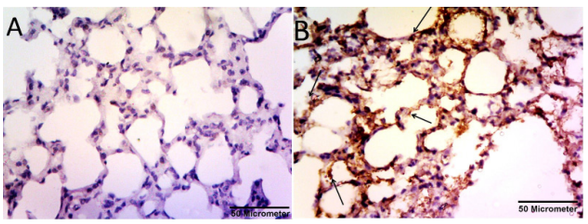


Fig. 1: Photomicrographs of cross sections in the rat lung stained with CD117 showing: (A): primary antibody is omitted (Negative control). (B)many c-kit-positive cells (arrows) after using secondary antibody (CD117 immunostaining X200).

Electron microscopic examination (TEM)

Tiny pieces (about 0.5 mm3) of the central one-third of the right uterine horns were removed and promptly treated with 3 percent glutaraldehyde and stored at 0 -4 degrees Celsius for 24 hours[20]. The sections were cut with a diamond knife on a LKB ultramicrotome. To begin, 0.5 m semithin sections were cut, picked up on a glass slide, and stained with toluidine blue for light microscopic examination[20]. Ultrathin sections (80nm) were cut and picked up on 200 mesh copper grids[21], stained with uranyl acetate[22], and lead citrate stain[20]. Sections were inspected and photographed using a transmission electron microscope (JEOL 100S Tokyo, Japan) at electron microscopic facilities at AL- Azhar University's college of medicine for females.

Morphometric and statistical studies

Morphometric measurements were made using a computerised image system that included a Leica Quin 500 image analyzer coupled to a Leica microscope. Telocytes (mean number of CD117 immunopositive cells) were counted in the endometrium and myometrium of each group tested. Ten non-overlapping fields from each group were inspected at a magnification of x100 using light microscopy relayed to the screen.

The whole statistical study was carried out using the statistical programme "Statistica for Windows" Version 5. The statistical analysis was conducted using the mean (M) and standard deviation (S.D) values as specified in[23]. Results were considered significant when probability (p) was ≤ 0.05 and highly significant when $P \leq 0.01$[21].

RESULTS

Immunohistochemical results

The uterus's cross-sections consisted of three layers from the inside outward: endometrium, myometrium, and perimetrium. Histologically, the endometrium was composed of a single layer of simple columnar epithelium epithelium overlying a thick layer of lamina propria containing endometrial glands. The myometrium

consisted of three layers inner circular (IC) middle stratum vascular (SV) and outer longitudinal layers (OL). Immunohistochemical stained sections revealed many c-kit-positive cells in all layers of the uterine wall of all studied groups. (Figure 2).

Endometrial telocytes exhibited as tiny, spindle- or pyriform-shaped cells with scanty cytoplasm and large oval nuclei with one or two long thin processes (telopodes)when stained with C-kit (CD117). In the endometrium, many c-kit-positive bodies' telocytes were commonly located in close contact with blood vessels, around endometrial glands and in-between stromal cells in all studied groups mainly in (GII) endometrium (Figure 3).

In the myometrium TCs were detected mainly in the (IC) layer of the myometrium, c-kit-positive telocytes were arranged in parallel orientation with smooth muscle fibers. Telocytes also detected in close relation to blood vessels of the (SV) layer and in-between smooth muscle fibers of the (OL) layer of the myometrium. In (GIII) there was an apparent increase in the number of c-kit-positive telocytes in the myometrium, especially in the (OL) layer. They were parallel to the (IC) smooth muscle and on the borders and in-between the (OL) muscles. Immunostained sections in the uterus of senile rats (GIV) revealed many c-kit-positive cells seen in the (IC) layer of the myometrium; arranged parallel. More commen in (GIII) than (GI) (Figures 4,5).

Semithin sections and Electron microscopic results

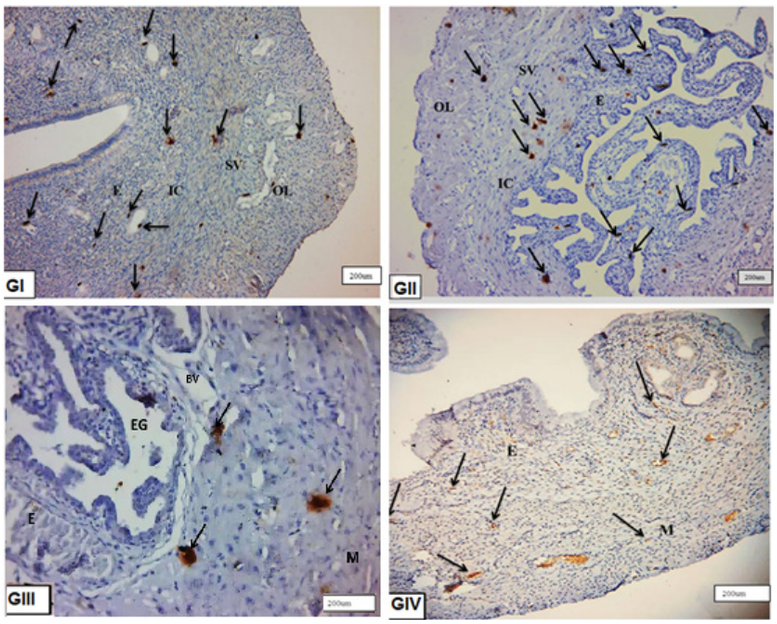
Semi-thin uterine sections stained with toluidine blue revealed the typical character of interstitial cells telocytes with tiny oval bodies and long thin processes (telepodes) in the endometrium, particularly surrounding endometrial glands, and in the endometrial stroma (Figure 6).

In the myometrium TCs exhibited a tiny body and distinctive telopodes located between myocytes of all groups, but mainly in (GIII) (Figure 7).

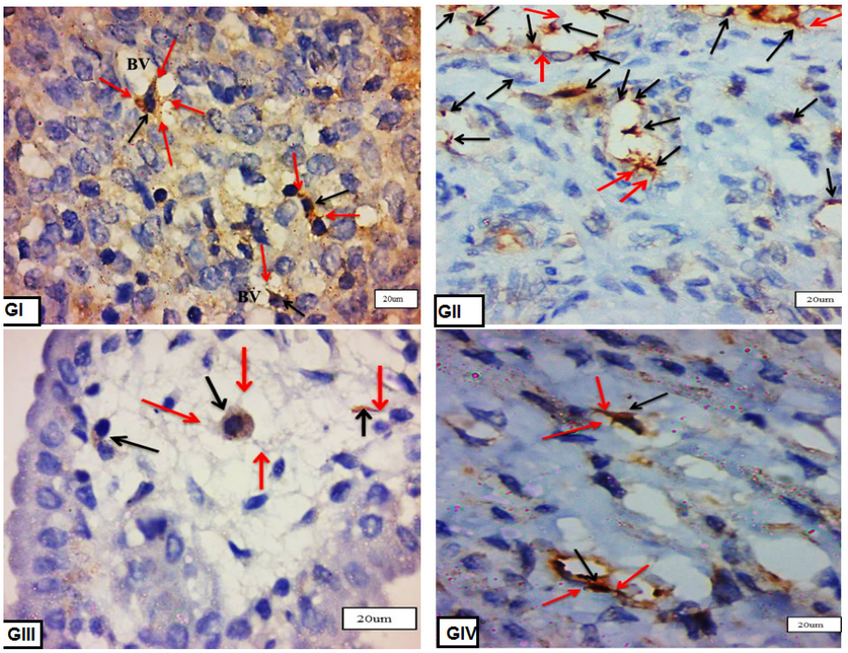
By TEM, the TCs had a tiny body surrounded by a small volum of cytoplasm including a central nucleus, organelles such as mitochondria and rough endoplasmic reticulum, polyribosome aggregations or glycogen granules, and other electron-dense bodies. Very long cellular extensions telopodes (1- 4) with alternating thin segments podomers and thick regions podoms extended from the body. TCs were detected in the endometrium lamina propria, just under the simple columnar epithelium, and surrounding the endometrial gland. TCs were absent in the basal lamina of (GII). There was a direct relationship between telopodes and longitudinal and transverse sections of collagen fibres along their course. Numerous telocytes were detected in the myometrium, mostly in the vicinity of blood vessels and in-between smooth muscle cells (Figures 8,9,10).

Morphometric and statistical results

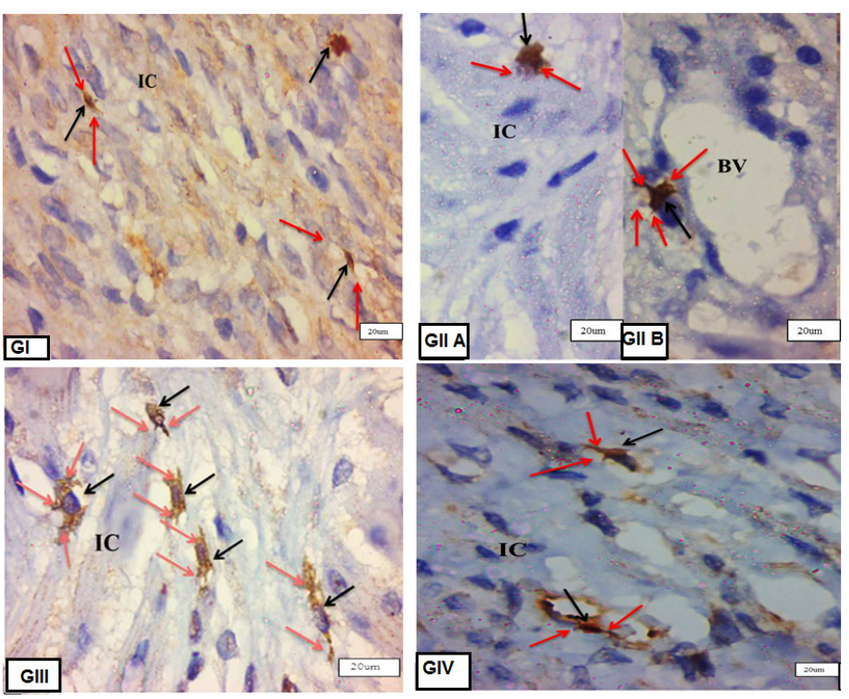
The mean number of TCs per ten HPF was determined by Image analysis. The current data was found that the mean number of TCs in the endometrium of (GI) was 8.29 ±1.11, (GII) was 13 ±1.16, (GIII) was 8.29 ±1.26, and (GIV) was 8.57 ±1.27. These findings were of statistically significant increase in (GII). As indicated in (Table 1, Histogram 1), the *P-value* was ≤ 0.05. While the mean number of TCSs in the myometrium of (GI) was 10.29±.76, (GII) myometrium was 5.43±.54, (GIII) was 15.14±.69 and (GIV) was 12.29±1.98. These findings were of statistically significant increase in (GIII) & (GIV) and statistically significant decrease in (GII). *P values* ≤ 0.05. (Table 1, Histogram 1).



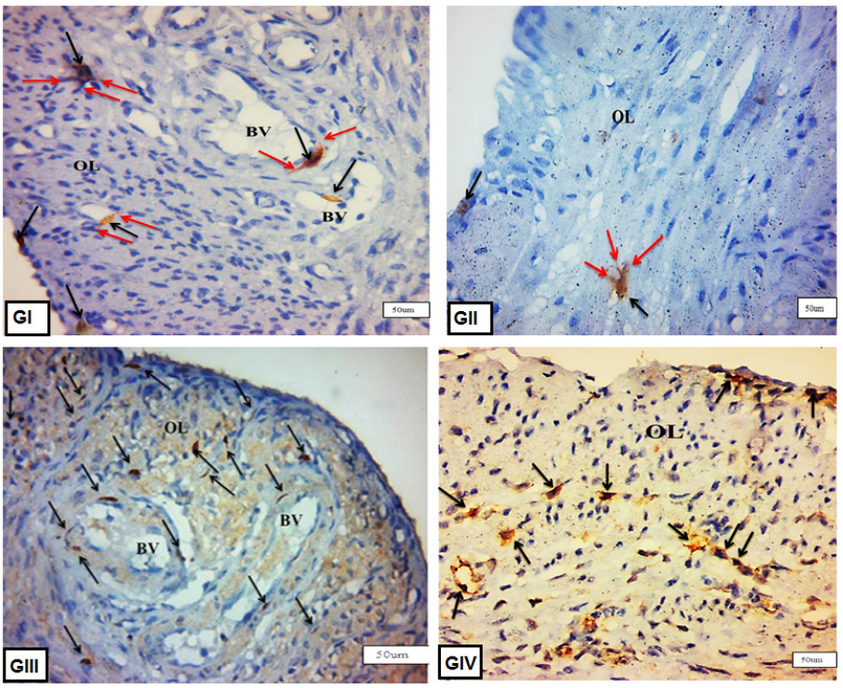
Figs. 2: Photomicrographs of cross sections in the rat uterus showing many c-kit-positive cells (arrows) in the endometrium (E) in-between endometrial stromal cells, near to blood vessels and around endometrial gland (EG),between myometrium (M), inner circular (IC), middle stratum vasculare (SV) and outer longitudinal (OL) smooth muscle layers in (GI), (GII), (GIII), (GIV). (CD117 immunostaining (GI, GII, GIV) & (GIII), X100).



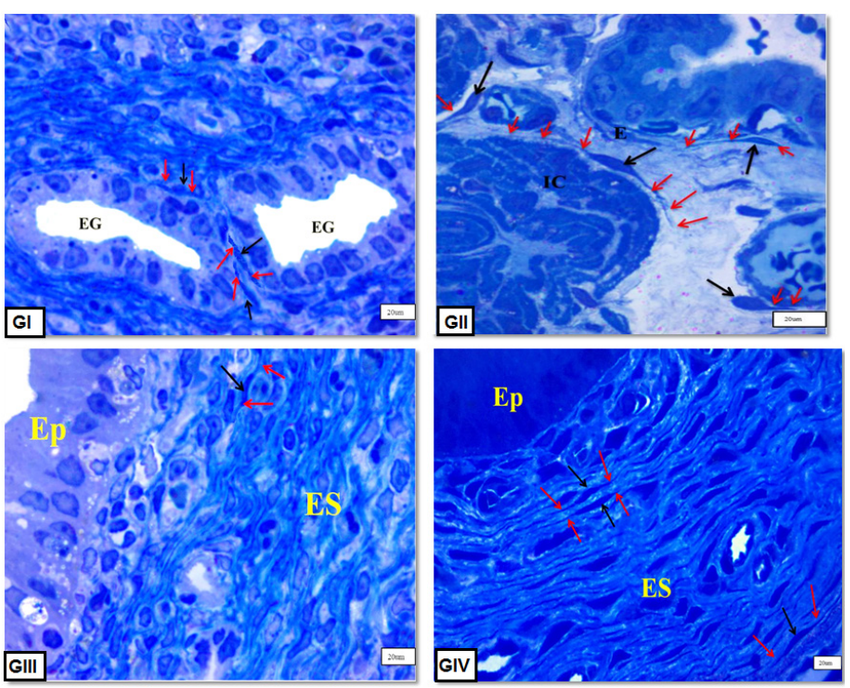
Figs. 3: Photomicrographs of cross sections in the rat uterus showing endometrium c-kit-positive cells telocytes (black arrows) with processes (telopodes) (red arrows), blood vessels (BV) in (GI), (GII), (GIII), & (GIV). (CD117 immunostaining X1000).



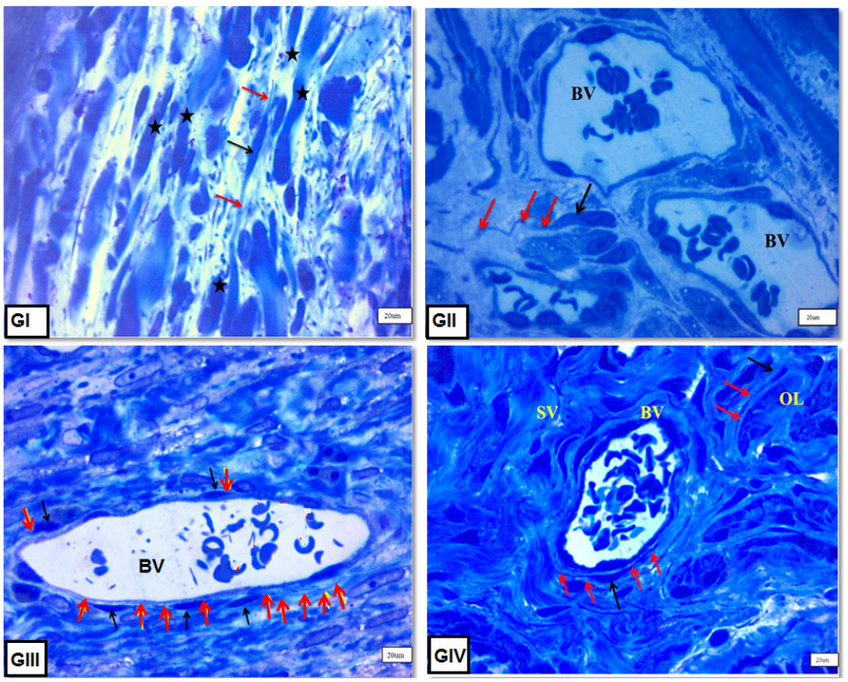
Figs. 4: Photomicrographs of cross sections in the rat uterus myometrium inner circular smooth muscle fibers (IC) layer showing many c-kit-positive cells telocytes (black arrows) with processes (telopodes) (red arrows), around blood vessels (BV) & inbetween muscle fibers (GI), (GII), (GIII), &(GIV) (CD117 immunostaining X1000).



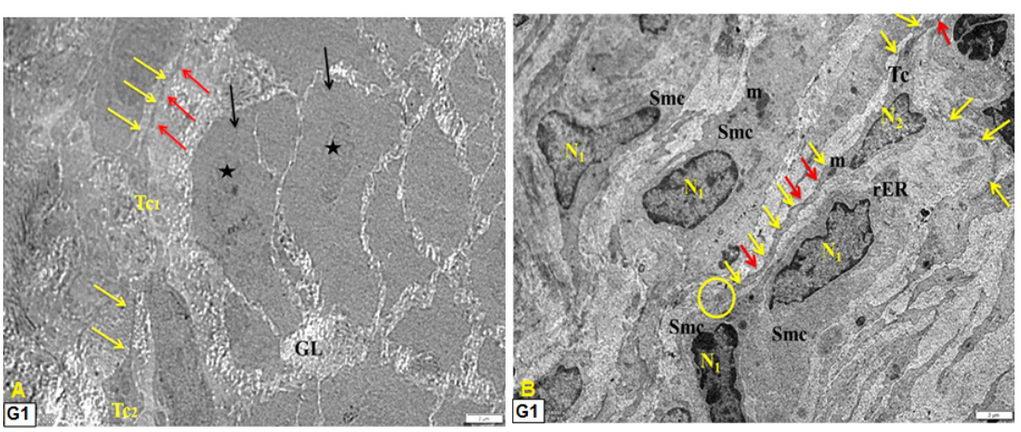
Figs. 5: Photomicrographs of cross sections in the rat uterus myometrium in the outer longitudinal muscle layer (OL) showing many c-kit-positive cells telocytes (black arrows) inbetween muscle fibers mainly in (GIII), around blood vessels (BV) in (GI), (GII), (GIII), &(GIV) (CD117 immunostaining X400).



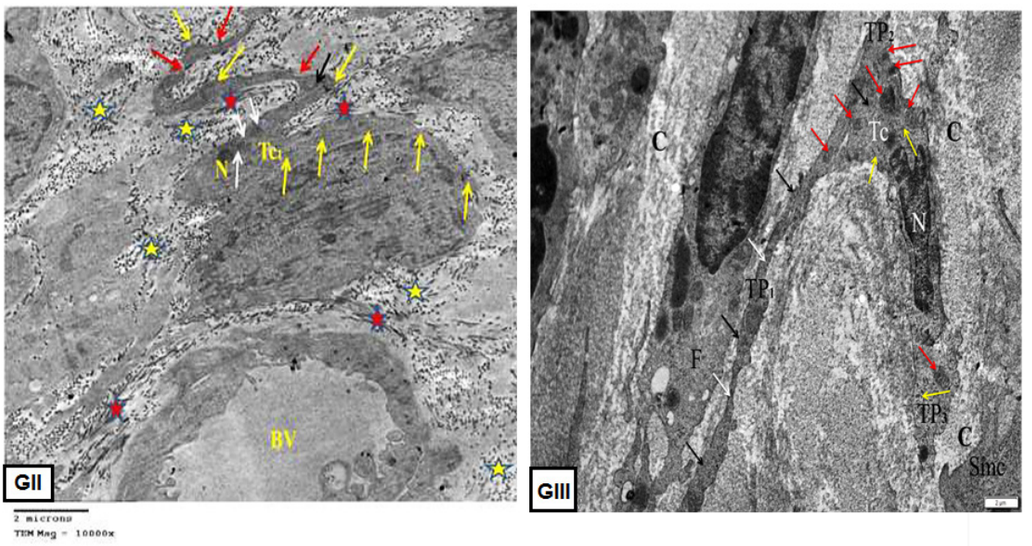
Figs.6: Photomicrographs of semithin sections in the endometrium showing that telocytes (black arrows), telopodes (red arrows) below surface epithelium (EP), in-between endometrial stroma (ES) and around endometrial glands (EG) in (GI), (GII), (GIII), &(GIV) . (Semithin, Toluidine blue, O.M, x1000).



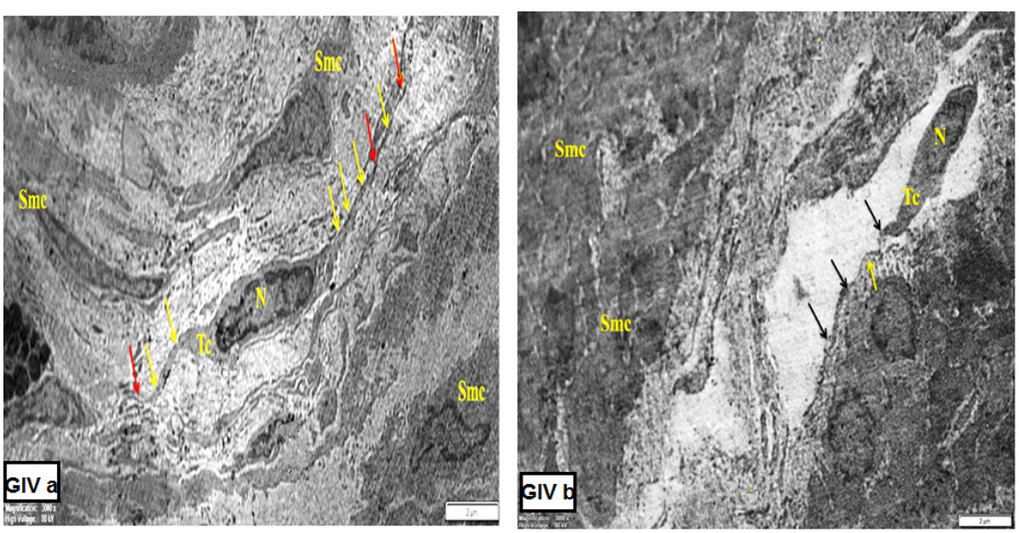
Figs.7: Photomicrographs of semithin sections in the myometrium of rat uterus showing telocytes (black arrows) ,telopodes (red arrows) in-between myocytes (stars) in the (OL) layers, and around congested blood vessels (BV) in stratum vascular (SV) in (GI), (GII), (GIII), &(GIV) . (Semithin,Toluidine blue, O.M, x1000).



Figs. 8: Electron micrographs of cross sections in the uterus of adult non-pregnant rat (GI) (A) Showing endometrium containing: endometrial gland with lumen (GL) with epithelium and nuclei (black arrow& star). There are two apparent telocytes (Tc1 & Tc2) with small cell podomers (yellow arrows) and podoms (red arrows) along the telopodes (B): showing myomertium with parallel arranged smooth muscle cells(Smc) with nuclus (N1), Telocyte (Tc) is present inbetween smooth muscles with a small body containing the nucleus (N2) and three apparent telopodes; podomers (red arrows), podoms (yellow arrows) and the encircled area showing the close connection of telopode with the adjacent Smc. Note, mitocondria (m), rough endoplasmic reticulum (rER). (O.M, x 4000).



Figs. 9: Electron micrographs of cross sections in: in the uterus of: (GII): pregnant rat myometrium with telocyte near to blood vessels (BV). Tc body with nucleus (N), mitochondria (white arrows), rER (black arrow) and twisted, long telopodes with podoms (yellow arrows) and podomers (red arrows). Note, collagen fibers, longitudinal (red star) and transverse (yellow stars) sections.
(GIII) postpartum rat showing a part of the myometrium containing (Tc) has nucleus (N), three telopodes (TP1,2&3), podomes (black arrows), podomers (white arrows). Note mitochondria (red arrows), aggregations of polyribosomes or glycogen granules (yellow arrows). smooth muscle cells (SMCs) with nucleus (N), Collagen fibers (C). (O.M, x X10000-8000 respectively).

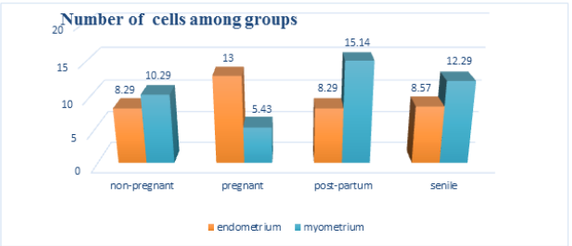


Figs. 10: Electron micrographs of cross sections in the uterus of Senile rats (GIV) myometrium with smooth muscle fibers (Smc) (a) showing (Tc) with nucleus (N) and long telopodes, Note, podoms (yellow arrows), podomers (red arrows), in-between. (b) Showing (Tc) with its cell body, nucleus (N) and telopodes (arrows) in the myometrium. Note, smooth muscle cells (Smcs), and podoms (black arrows). (O.M X3000)

Table 1: Statistical analysis of the number of telocytes / 10 HPF in the endometrium and myometrium of adult and senile female albino rats

	Non pregnant (A) M±SD (GI)	Pregnant (B)M±SD (GII)	Postpartum (C) M±SD (GIII)	Senile (D)M ± SD (GIV)	*P-value*	Post hoc
Endometrium	8.29±1.113	13 ± 1.155	8.29 ± 1.254	8.57 ± 1.27	.000	B-A, B-C B-D
Myometrium	10.29 ± .756	5.43 ± .535	15.14 ±.690	12.29±1.976	.000	A-B,A-C A-D

HPF= High Power Fields. M = mean SD = standard deviation -$p > 0.05$ statistically significant.



Histogram 1: Comparison between the four studied groups as regard number of telocytes / 1 in the endometrium and myometrium of adult and senile female albino rats

DISCUSSION (MORE EXPLANATIONS RELATING DIFFERENCE IN COUNT IN RELATION TO FUNCTION)

Telocytes TCs, previously known as interstitial Cajal-like cells (ICLCs), have been described in practically every organ of the human body in recent years[25,26]. The present study demonstrated the presence of TCs in the endometrium and myometrium of rat uterus in various reproductive states (adult non-pregnant (GI), pregnant (GII), postpartum (GIII), and senile (GIV)) using toluidine blue staining, immunohistochemistry with anti-tic-kit antibodies, and transmission electron microscopic analysis.

In this work TCs appeared as tiny, pyriform, or spindle-shaped cells with long, thin, and few telopodes (2–5). This is consistent with Cristian *et al*.,[25] 's findings about TCs in the subepicardial niche. According to Przemysław *et al*.,[18], Telopods may reach a length of 1000 µm, making them one of the longest structures in the body, save for certain axons. Furthermore, unlike CD 34, c-kit was shown to stain primarily the cell body of TCs with a lower affinity for staining the cell processes. Salama,[27] and Ivan *et al*.,[17] agreed on this point.

Semithin sections of uterine fragments stained with toluidine blue were suitable for assessing the distribution of TCs with their small cell body with long and thin (Tps). throughout the uterus. This is consistent with the findings of Zheng *et al*.,[28] who investigated uterine telocytes.

Telocytes were detected using TEM in the endometriums of all examined groups, mostly near endometrial glands, endometrial blood vessels, and between endometrial stromal cells. This is consistent with the findings of Przemyslaw *et al*.,[18], who study TCs in female reproductive system and demonstrated the uterine stromal cells. It could be postulated that TCs may act as a scaffold in endometrial maintenance, glandular support and stromal cell communication. Additionally, TCs are abundant around blood vessels, where they are involved in tissue homeostasis, remodelling, assisting in the development of new blood vessels (angiogenesis), suppressing oxidative stress and cellular ageing, and protecting against inflammation and oncogenesis[29].

In the present study, there was no significant difference in the number of TCs in the endometrium of (GI) and (GIII), but the highest count of endometrium TCs was detected in (GII). These findings were consonant with the results of Przemysaw *et al*[18]. Additionally, there was no significant difference in the quantity of TCs in the endometrium of (GIV) vs controls (GI). The morphometric analysis corroborated these findings. Hence,Hatta *et al*[30], postulated that TCs are are frequently present in tissues with a low cell density and large space between neighboring cells. This hypothesis could be supported by the present finding that the pregnant group had a significantly higher number of endometrial TCs than the other groups, as the endometrium, unlike the myometrium, becomes looser and loses cellularity during pregnancy, necessitating the presence of more TCs to facilitate cell-to-cell contact over long distances[27,18].

Additionally, the present study established the existence of c-kit-positive TCs in the myometrium of all groups investigated. This data corroborates Veronika *et al*[31]'s discovery that TCs comprised around 7% of the overall cell population in non-pregnant myometrial cell culture and approximately 3% of the total cell population in the myometrium of adult non-pregnant individuals.

Myometrial TCs were suggested to play a c-kit-dependent central role in the generation and coordination of myometrial contractility[32]. Additionally, TCs possess excitatory and inhibitory neurotransmitter receptors and are capable of transmitting nerve impulses to smooth muscle cells, where they participate in mechanoreception[29]. Experimental studies indicated that TCs may be involved in the spontaneous contraction of the uterus[11]. This may have happened as a result of the hormonal influence, since uterine TCs have been shown to express oestrogen and progesterone receptors, operate as steroid sensors, and contribute to the coordination of human myometrial contractions and pregnancy maintenance[26,32].

The current morphometric analysis demonstrated that the number of myometrial TCs was significantely lower in (GII), and significantly greater in (GIII) and senile uteri (GIV) respectively compared to adult non-pregnant uteri (GI). This observation might be explained by the fact that the number of myometrial TCs is decreased during pregnancy to avoid early uterine contractility and preterm birth, but the number of myometrial telocytes is raised postpartum to promote myometrial contraction during uterine involution[27,18]. There are no published data on the number of TCs in the senile uterus, but it may have risen to adjust to the wide muscle separation caused by extra collagen fibres or may have reacted to any low levels of steroid hormones due to its oestrogen and progesterone receptors.

Telocytes make extensive connections with neighbouring cells, forming a unique three-dimensional network inside interstitial tissues. These structural characteristics underpin the suggested numerous roles of TCs[32]. Additionally, uterine TCs form linkages with other extracellular matrix components (for example, collagen fibres)[18].

CONCLUSION

Telocytes increased in the endometrium of pregnant uteri and the myometrium of postpartum and senile uteri, but decreased in the pregnant uterus myometrium.

RECOMMENDATION

Additional research is required to describe uterine TCs during parturition. Gaining a better knowledge of uterine TCs may aid in the development of therapeutic options for dysmenorrhea, recurrent pregnancy loss, and preterm delivery.

ACKNOWLEDGEMENT

The authors would like to acknowledge the guidance provided by colleagues in the histology laboratory and electron microscopic unit in the faculty of Medicine (Girls), Al-Azhar University.

CONFLICT OF INTERESTS

There are no conflicts of interest.

REFERENCES

1. Cajal, R. S. (1911). Histologie du systeme nerveux de l'Homme et de Vertebres.Paris: Maloine.
2. Popescu L., Ciontea S., Cretoiu D., Hinescu M., Radu E., Ionescu N., Ceausu M., Gherghiceanu M., Braga R., Vasilescu F., Zagrean L. & Ardeleanu C. (2005). Novel type of interstitial cell (Cajal-like) in human fallopian tube. J Cell Mol Med. 9:479-523.
3. Popescu, L. M., Manole, C. G., Gherghiceanu, M., Ardelean, A., Nicolescu, M. I., Hinescu, M. E. and Kostin, S. (2010). Telocytes in human epicardium. J. Cell Mol. Med. 14, 2085-2093. doi:10.1111/j.1582-4934.2010.01129.x
4. Ayano Kondo and Klaus H. Kaestner (2019): Emerging diverse roles of telocytes | Development 146, dev 175018. doi:10.1242/dev.175018.
5. Chen, X., Zheng, Y., Manole, C. G., Wang, X. and Wang, Q. (2013). Telocytes in human oesophagus. J. Cell Mol. Med. 17, 1506-1512. doi:10.1111/jcmm.12149
6. Hennig G., Spencer N., Jokela-Willis S., Bayguinov P., Lee H., Ritchie L., Ward S., Smith T. & Sanders K. (2010): ICC-MY coordinate smooth muscle electrical and mechanical activity in the murine small intestine. Neurogastroenterol. Motil. 22 (5): 138–151.
7. Martin Klein, Mária Csöbönyeiová, Stanislav Žiaran, L'uboš Danišovi˘c and Ivan Varga (2021): Cardiac Telocytes 16 Years on—What Have We Learned So Far, and How Close Are We to Routine Application of the Knowledge in Cardiovascular Regenerative Medicine? Int. J. Mol. Sci., 22, 10942.
8. Kostin, S. (2010). Myocardial telocytes: a specific new cellular entity. J. Cell Mol. Med. 14, 1917-1921.
9. Corradi, L. S., Jesus, M. M., Fochi, R. A., Vilamaior, P. S., Justulin, L. A.Jr, Góes, R. M., Felisbino, S. L. and Taboga, S. R. (2013). Structural and ultrastructural evidence for telocytes in the prostate stroma. J. Cell Mol. Med. 17, 398-406. doi:10.1111/jcmm.12021.
10. Vilessa Lilian de Araújo Gomes, Janine Karla França da Silva Braz, Gabriel Moura Martins, Naianne Kelly Clebis, Moacir Franco de Oliveira, Danielle Barbosa Morais, Carlos Eduardo Bezerra de Moura (2021) Identification of telocytes in dystrophic mice testis einstein (São Paulo).;19:1-2.
11. Cretoiu, S. M., Cretoiu, D. and Popescu, L. M. (2012a). Human myometrium – the ultrastructural 3D network of telocytes. J. Cell Mol. Med. 16, 2844-2849.
12. Suciu, L., Popescu, L. M., Gherghiceanu, M., Regalia, T., Nicolescu, M. I.,Hinescu, M. E. and Faussone-Pellegrini, M. S. (2007). Telocytes in human term placenta: morphology and phenotype. Cells Tissues Organs 192, 325-339.
13. Wang J., Meiling J., Wen-huan M., Zhitu Z. & Xiangdong W. (2016): The History of Telocyte Discovery and Understanding. Adv Exp Med Biol. 913: 1-21.
14. Maria Giuliana Vannucchi (2020): TheTelocytes: Ten Years after Their Introduction in the Scientific Literature. An Update on Their Morphology, Distribution, and Potential Roles in the Gut Int. J. Mol. Sci. 21, 4478.
15. Li Wang, Li Xiao, Ruzhi Zhang, Huiling Jin & Haixia Shi (2020): Ultrastructural and immunohistochemical characteristics of telocytes in human scalp tissue. Scientific Reports 10:1693.
16. 16. Lucio Díaz-Flores, Jr. and José Luis Carrasco 1(2020): Telocytes in the Normal and Pathological PeripheralNervous System Int. J. Mol. Sci., 21,: 4320.
17. Ivan V., Stefan P., Jan K., David K., L'ubos D. & Martin K. (2019): Recently Discovered Interstitial Cell Population of Telocytes: Distinguishing Facts from Fiction Regarding Their Role in the Pathogenesis of Diverse Diseases Called "Telocytopathies". Medicina. 55, : 56.
18. Przemysław J., Iwona K., Małgorzata R. & Hubert H. (2018). Telocytes in the female reproductive system. Advances in Clinical and Experimental Medicine, 27 (4),: 559-565.
19. Bancroft J. & Gamble M. (2015): Theory and Practice of Histological Techniques. 6th ed. Churchill Livingstone, Edinburugh, London, Melbourne. 201-217.
20. Robinson D., Ehlers U., Herken U., Herrmann B., Mayer F. & Schurmann F. (1987): Method for preparation for electron microscopy. An introduction to the biochemical sciences. Muhlethaler K. Springer-verlag. Berlin, Heidelberg, New York-London-Paris-Tokyo. 23- 52. ISBN: 3-540-17592-X.

21. William W. & Carter C. (1996). Transmission electron microscopy. A Text Book For Material Science, 2nd edition, Springer Verlag. Heidelberg. New York. London. 721-756.

22. Johanneseen J. (1978): Electron microscopy in humn medicine. Instruments and Techniques. McGraw Holl international book company, New York, San Francisco, London; 1: 20-57.

23. Mould R. (1989). Introductory medical statistics. 2nd ed, Adam Hilger, Bristol, and Philadelphia. 17: 22.

24. Armitage P. & Berry G. (1994): Statistical methods in medical research. 3rd Oxford Blackwell Scientific Publication. 1-10.

25. Cristian B., Mugure C., Laurenţiu M., Sorin H. & Oana D. (2019). The Telocytes in the Subepicardial Niche. Applied Science. 9 (8), 1615; 1- 15.

26. Soliman S.A. (2021). Telocytes are major constituents of the angiogenic apparatus. Scientific Reports 11: 5775.

27. Salama N. (2013). Immunohistochemical characterization of telocytes in rat uterus in different reproductive states. Egyptian Journal of Histology. 36: 185–194.

28. Zheng Y., Bai C. & Wang X. (2012). Telocyte morphologies and potential roles in diseases. Journal of cellular physiology. 227: 2311–2317.

29. Abdel-Maksoud F., Abd-Elhafeez H. & Soliman A. (2019). Morphological changes of telocytes in camel efferent ductules in response to seasonal variations during the reproductive cycle. Scientific Reports. 9 : 4507.

30. Hatta K., Huang M., Weisel R. & Li R. (2012). Culture of rat endometrial telocytes. J Cell Mol Med. 16: 1392–1396.

31. Veronika A., Jerzy A. & Krzysztof G. (2016). Telocytes in female reproductive system (human and animal). J Cell Mol Med. 20(6): 994–1000.

32. Tang X., Zhang F., Jiang X. & Yang X. (2019). Telocytes enhanced the proliferation, adhesion, and motility of endometrial stromal cells as mediated by the ERK pathway in *vitro*. 11 (2):572-585.

الملخص العربى

تركيب وتنسيق الخلايا ذات الامتدادات في رحم الجرذان: دراسة مناعيه وتركيبية دقيقة

فاطمة الزهراء عبد الله عزيز، ايمان سعيد محمود، رانيا محمد النبوي

قسم الهستولوجيا وبيولوجيا الخلايا، كلية طب البنات، جامعة الأزهر، القاهرة

الخلايا ذات الامتدادات البعيدة (Telocytes) نوع من الخلايا البينية التي اكتشفت حديثا في معظم اعضاء الجسم ومن بينها الرحم. فهى ضرورية لتنسيق الانقباضات العضلية الرحمية ومسئولة عن تقلص الرحم العفوي النتظم اثناء المخاض وتساعد علي اتمام الحمل ومنع الولادة المبكرة والنزيف الرحمي بعد الولادة.

أجرى هذا البحث بهدف دراسة تركيب وتنسيق وتوزيع الخلايا البينية ذات الامتدادات البعيدة بجدار رحم اناث الجرذان البيضاء البالغة والمسنة.

أستخدم فى هذة الدراسة ٢٤ من إناث الجرذان البيضاء السليمة ظاهريا البالغة (غير الحوامل – الحوامل – بعد الولادة) والمسنة حيث قسمت فى التساوى الى اربعة مجموعات:

المجموعة الأولى: الجرذان البالغة غير الحوامل والمجموعة الثانية: الجرذان الحوامل في اليوم ال ١٦-١٨ من الحمل والمجموعة الثالثة: الجرذان البالغة في اليوم الثالث بعد الولادة والمجموعة الرابعة: الجرذان المسنة

تم أخذ العينات من الثلث الوسطى للقرن الأيمن من رحم الجرذان وتم التمرير والصباغة والفحص المجهري مستخدمين المجهرين الضوئى للعينات المعالجة بصبغة الهستوكيميائية المناعية ضد سى كيت وصبغة التلودين الأزرق للقطاعات شبة الرقيقة.

وللفحص بالمجهر الالكترونى النافذ للقطاعات الرقيقة المصبوغة بخلات اليورانيل وسترات الرصاص .وتم عمل القياسات الكمية بجهازالتحليل الضوئى ثم اخذ القيم المتوسطة وتحليليها إحصائيا لمعرفة الدلالة المعنوية لجمييع العينات التى تم دراستها.

وقد ظهرت الخلايا ذات الامتدادات في بطانة وكذلك في عضل الرحم الجرذان البالغة الغير حوامل والتي ظهرت علي شكل خلايا جسمها صغير ولها إطلالات سيتوبلازمية مميزة طويلة ومتعددة(telopodes) وكانت هناك زيادة واضحة لها دلالة إحصائية في عدد الخلايا ذات الامتدادات في بطانة الرحم للمجموعة الثانية مع إنخفاض له دلالة إحصائية فى عددها فى عضل رحم الجرذان الحوامل لنفس المجموعة. كما توجد زيادة واضحة ذات دلالة إحصائية في عدد هذه الخلايا في عضل رحم المجموعة الثالثة و الرابعة.