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Research Article

The Role of The Fallopian Tube in Performance Of The Main Myometrial Functions

QV Kazaryan*, NG Hunanyan, TA Piliposyan, RG Chibukhchyan and AV Mkrtchyan

L.A. Orbeli Institute of Physiology, NAS RA, Yerevan, Armenia

***Corresponding Author:** QV Kazaryan, L.A. Orbeli Institute of Physiology, NAS RA, Yerevan, Armenia.

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Abstract

The relationship between the spontaneous electrical activities of paired fallopian tubes, and, accordingly, each of them with the uterine corpus, was studied by stepwise transections. The stability of rhythmogenesis of the left uterine horn was revealed in case of the both experimental conditions- when the right horn or the left horn itself was isolated. Transection of the right fallopian tube contributes to decrease in the values of such parameters of activity as the amplitude and rise-rate of action potentials (almost by 10 %) in the left fallopian tube. It has also been shown that the values of similar parameters of electrical activity were decreased in the uterine corpus after transection of the right (the amplitude - by 29.83% and the rise - rate - by 17.6%), then the left (by 36.67% and 16 % respectively) uterine horns.

Based on the results obtained in these experiments, we assume that the left uterine horn has a unique stability of automatism and, at the same time, it is in a certain functional relationship with the uterine corpus.

Keywords: Myometrium; Spontaneous Electrical Activity; Left and Right Fallopian Tubes (Uterine Horns); Uterine Corpus; Transection; Relationship

Abbreviation

AP: Action Potential

It is well known that the main function of the myometrial tissue is accomplished by propagation of electric waves in the caudal direction along the entire reproductive organ [1,2]. The polarity of this process is regulated by the coordination of electrical activity in the certain rhythmogenic areas. Meanwhile, pacemaker activity of the smooth muscles is represented by fast APs grouped into periodically occurring bursts that are closely associated with contraction: each burst of spikes is accompanied by a burst of contraction with a short delay [3-5].

Myometrial smooth muscle tissue differs in its characteristics, in particular, it has a syncytial organization, which is inherently myogenic and characterized by the certain innervation [14]. This tissue also has pacemaker areas in specific locations [6]. In this case, it can be stated that electrical activity conduction and, accordingly, contractions are determined by the location of these areas. Indeed, according to a number of studies, the rhythmogenic area located in the ovarian horn region has a leading role in the regulation of the propagation of electrical waves and in their direction [4,7,8].

The study of pacemaker activity in the ovarian horn areas has revealed a certain specifity of the electrophysiological characteristics in this region in comparison to those in other rhythmogenic areas of myometrium. In particular, spikes are more uniformly distributed in bursts and the frequency range is rather wide - from 30 to 120 oscillations/min, recorded action potentials have stable high amplitudes [9]. Acording to the literature data, this

fact also confirms the leading role of the ovarian horn area and its ability to coordinate the electrical events in the remaining active areas of myometrium [10-12].

Reproductive organ pushes the fetus out from the paired fallopian tubes, into the uterine corpus. Meanwhile, each horn is an autonomous organ [1,13,19] and ensures the integrative functional activity of the entire reproductive system and thus affects the automatism of the uterine corpus. Based on this, a question arises regarding identification of the relationship between pacemaker activities of the left and right ovarian horn areas and the uterine corpus (Figure 1), which are characterized by their own electrical rhythms. Paired fallopian tubes, in turn, have identical physiological properties, which may contribute to their reserve capacities. Thus, it is of great interest to study the influence of each fallopian tube, as well as the uterine corpus, on the functional activity of the entire reproductive system. The present paper challenges to clarify this question.

Figure 1: Schematic diagram of the rat uterine horns. 1,2,3 are the corresponding registration areas from the left and right ovarian horn regions and from the uterine corpus; I and II are the corresponding transection areas.

Materials and Methods

Experiments were carried out under in situ conditions on female rats weighing 200-250g. Animals were anesthetized by intraperitoneal injection of Nembutal (40-45 mg/kg). All experiments were acute and the animals were killed after registrations had been completed. The abdominal cavity was opened by performing a medial incision of the abdominal wall and the fallopian tubes with the uterine corpus were exposed. The uterus was denervated by transection of the nerves plexus hypogastricus, uterinus, uterovaginalis. Registration was performed simultaneously from surface of the both ovarian horn areas and the uterine corpus (Figure 1).

Spontaneous electrical activity of the above mentioned areas was registered by bipolar electrodes (the interelectrode distance corresponded to 2 mm). Rhythmogenic regions were isolated from each other by transection of the uterine horns in the corresponding I and II areas: transection of the left and right ovarian horn areas, respectively, from the uterine corpus was done (Figure 1).

The amplitude (A), mean rise - rate (V), rise-time (T/2 - action potential duration of upgoing phase) and half width (t - action potential duration forming the upper half of its amplitude) of peaks of spontaneous action potentials (AP) were determined. All parameters were determined by averaging twice - within one experiment and all experiments.

Spontaneous electrical activity of smooth muscles was recorded by an 8-channel device developed at the L.A. Orbeli Institute of Physiology of NAS RA [22]. Simultaneous registration was carried out from 3 loci of the structure under study. The signal-to-noise ratio of the device allows conducting a reliable registration of signal deviations with an amplitude of ≤0.01 μV. The device communicated with computer by USB port.

The signal registration program was developed by using the Lab View-V 2018 software. The subsequent statistical analysis of recorded signals was carried out by using the Origin-8.5 and Sigma Plot 11.0 softwares. Student's t-test was used to determine statistically significant changes. Control was assumed to be 100% and all measurements were presented as percentages of the control. The given records of individual experiments show electrical activities recorded in one of experiments. Registrations were done on 19 animals.

All experiments were carried out in accordance with the rules of the "European Convention for the Protection of Animals used in Experiments" (Directive 2010/63/EU).

Results and Discussion

Based on the above, intrinsic autonomous rhythmogenesis is a fundamental feature of organs constituting the reproductive system, particularly the right and left fallopian tubes. At the same time, each of them has specific electrical activity with different values of parameters [12,15,20]. Simultaneous registration of bursts of the spontaneous activity in three myometrial regions is shown in Figure 2. Meanwhile, the left ovarian horn area is characterized by significantly greater parameters of action potentials in comparison with the right ovarian horn area and the uterine corpus (Table 1).

Registration areas and number of experiments, n	Amplitude of action potentials (A), μV	Rise-rate of action potentials (V), μV/sec.	Rise-time of action potentials (T/2), sec.	Half width of action potentials (t), sec.
Left ovarian horn area (1), n = 19	75,34 ± 0,84	1006,47 ± 44,20	0,06 ± 0,00	0,06 ± 0,00
Right ovarian horn area (2), n = 19	58,09 ± 2,76	766,90 ± 4,14	0,06 ± 0,00	0,05 ± 0,00
Uterine corpus (3), n = 19	50,90 ± 3,13	50,90 ± 3,13	0,06 ± 0,00	0,05 ± 0,00

Table 1: Parameters of action potentials registered in the ovarian horn areas and uterine corpus in norm.

Figure 2: Spontaneous electrical activities of the left (area 1, figure 1) and right (area 2, figure 1) ovarian horn areas and the uterine corpus (area 3, figure 1) of myometrium in norm. Averaged contours of single AP bursts are shown on the right.

Due to complex interactions between the rhythmogenic areas of rat myometrium [17,18] electrical activity of each horn can influence another one of paired fallopian tubes. Thereby, it can be supposed that functional identity of the both fallopian tubes does not exclude the existence of certain differences in their electrophysiological parameters. This problem was studied by stepwise isolation of rhythmogenic areas of the myometrium (Figure 1).

Comparative analysis of changes in the characteristics of automatism after corresponding transections in relation to norms has revealed a significant decrease (by 36.7%) in amplitude of the action potentials in the right uterine horn. This parameter is considered as one of the most important and informative in literature [21] and surprisingly, it was decreased by only 7-8% in the left uterine horn.

Figure 3: Parameters of electrical activity in the isolated right and left uterine horns. A- Percentage ratio of the right horn parameters after right horn transection to the norm (dashed line) B. Overlay of AP average forms of the right horn in norm (solid line) and after its transection (dashed line). C. Percentage ratio of AP parameters of the left horn after its transection to the norm (dashed line) D. Overlay of AP average forms of the left horn in norm (solid line) and after its transection (dashed line). n = 19.

Thus, the above fact may indicate that the left and right uterine horns are endowed with independent automatisms (Figure 3).

The next series of experiments was conducted to study the relationship between paired fallopian tubes. Isolation of the right uterine horn, then - the left was performed. Right horn transection effect on the left was following: activity parameters showed a slight decrease, the amplitude and rise - rate of APs dropped by almost 10 % (Figure 4). This evident confirms that left fallopian tube generates a stabile autonomous activity which is not affected much by transection of the right horn. At the same time, left horn isolation contributes to a greater change in AP characteristics: the amplitude decreases by almost 20% and the peak rise rate - by 24.5 %. Meanwhile, the values of rise-time and half width of spontaneous APs almost had not been changed (Figure 4).

The study of the effect of fallopian tubes electrical activity on the automatism of the uterine corpus was carried out by stepwise transection: the right uterine horn was isolated from organ the first in order to exclude its influence on spontaneous activity of the uterine corpus. According to Figure 5 there is a decrease in the amplitude of action potentials by 29.83%, the rise-rate was less affected (decrease by 17.6%) and characteristics of the other parameters of rhythmogenesis remained unchanged (Figure 5). Subsequent isolation of the left fallopian tube already resulted in greater change of the values of the main activity parameters in the uterine corpus (the amplitude was reduced by 36.67% and the rise-rate was reduced by 16 %) (Figure 5). Taking into consideration the changes in activity parameter values presented in this figure, we can definitely conclude that the amplitude of action potentials in the uterine corpus was influenced by the corresponding transections of the fallopian tubes.

Figure 4: Effect of stepwise transections (right horn, then left) on activity of the left horn. A. Percentage ratio of the left horn parameters after right horn transection to the norm (dashed line) B. Overlay of AP average forms of the left horn in norm (solid line) and after right horn transection (dashed line). C. Percentage ratio of AP parameters of the left horn after its transection to the norm (right horn had been transected before, dashed line) D. Overlay of AP average forms of the left horn after right horn transection (solid line) and its transection (dashed line).

Figure 5: Effect of stepwise transections (right horn, then left) on activity of the uterine corpus. A. Percentage ratio of uterine corpus parameters after right horn transection to the norm (dashed line) B. Overlay of AP average forms of the uterine corpus in norm (solid line) and after right horn transection (dashed line). C. Percentage ratio of AP parameters of the uterine corpus after left horn transection to the norm (right horn had been transected before, dashed line) D. Overlay of AP average forms of the uterine corpus in norm (right horn had been transected before, solid line) and after left horn transection (dashed line).

A comparative analysis of the activity parameters of both fallopian tubes revealed certain differences between their values, with a higher electrical activity inherent in the left fallopian tube [16]. Perhaps, this fact ensures the existence of some dissimilarity in the functional properties between right and left horns. At the same time, these organs work in a complex manner and provide the movement of fetus to the uterine corpus and, thus, realizing the main role of the entire reproductive system.

The fallopian tubes are paired structures and apparently, they have reserve capabilities for performing the main function. Very interesting is the fact that isolation of the left uterine horn from neighboring organs mostly does not affect its activity (Figure 4). As noted above, the left uterine horn, probably, related with its inherent higher functional activity in norm, remains resistant to the conditions of its isolation, which means the characteristics of its activity do not change. Moreover, according to Figure 5, it has a relatively greater functional relationship with the uterine corpus and is able to compensate the "lack" of influence of the right uterine horn on the uterine corpus.

All the above-mentioned statements, of course, are preliminary and require further research.

Summary

- It is well known that the main function of the myometrial tissue is accomplished by propagation of electric waves in the caudal direction along the entire reproductive organ. The polarity of this process is regulated by the coordination of electrical activity in the rhythmogenic areas.
- According to the literature data, the ovarian horn area has a leading role in coordinating the electrical events of myometrium. Meanwhile, each horn is an autonomous organ and ensures the integrative functional activity of the entire reproductive system and thus affects the automatism of the uterine corpus.
- Based on this, a question arises regarding identification of the relationship between pacemaker activities of the left and right ovarian horn areas and the uterine corpus.
- Current study has revealed certain differences between the activity parameters of both fallopian tubes, with greater values inherent for the left fallopian tube.
- Moreover, the left fallopian tube had a relatively greater functional relationship with the uterine corpus and is able to compensate the "lack" of influence of the right uterine horn (in case of transaction) on the uterine corpus.
- In case of any pathology in one of the fallopian tubes, second is able to compensate and take the main function on it. Better compensation is awaited from the left fallopian tube is more active in norm.

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