RECEPTIVE RELAXATION AND POST-OVULATORY MOTILITY PATTERN OF THE OVIDUCT IN CONSCIOUS RABBITS

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Summary: Diametric changes of the oviductal isthmus were recorded in 6 conscious rabbits using the technique of impedance plathysmography through an electrode encasement implanted around the isthmus which also allowed the simultaneous recording of electrical spikes. The baseline activity of the isthmus indicated impedance waves of 10.12 ± 0.06 ohms with a frequency of 10.24 ± 0.62 per min. The area covered by these waves was 5.48 ± 0.18 $cm^2/30$ sec. The electrical spike frequency was 4.36 ± 0.22/min.

Administration of hCG led to a marked decrease in the activity of the oviductal isthmus within 4 hr. This phase of decreased activity which has been termed as *receptive relaxation* lasted for 6-8 hr. The activity/motility of the isthmus then started increasing reaching a peak level (X 3-4 of basal values) by about 48 hrs after which the process of restitution was started taking the motility back to the control level by 72 hr. The ova-positioning experiments indicated that the ova at 48 hr after hCG were in the ampulla or ampulloisthmic junction. The phenomenon of receptive relaxation corresponds well with the time of ovulation. On the basis of the present study it is also hypothesised that the increase in the motility of oviductal isthmus does not serve to propel the ova towards the uterus. Instead it resists the transport of ovum and serves to retain it in the ampulla.

Key words: oviduct oviductal isthmus ovum transport receptive relaxation oviductal motility

INTRODUCTION

There have been a number of publications on the role of oviductal motility in ovum transport (3,4,5,10). However, the exact mechanisms which the oviduct employs to bring about changes in the rate of ovum transport are still not clear. This seems to be due to the lack of appropriate techniques for *in vivo* recording of oviductal contractility in a conscious animal. A recent report indicates that impedance changes across the oviductal wall represent faithfully the contraction induced diametric changes at the segment of oviduct where impedance is measured (6). We have recorded motility of the oviductal isthmus in the conscious rabbit in terms of impedance changes with the help of an electrode implant which can be chronically fixed around different segments of the oviduct. The technique also permitted the simultaneous recording of electrical spikes from the same oviductal segment. This paper describes the motility pattern of oviductal isthmus achieved on ovulation induced by the administration of hCG in the conscious rabbit and reports in addition that at the time of ovulation the oviduct goes into a phase of relaxation. To the best of our knowledge, this phenomenon which we have termed as *receptive relaxation* has not been reported before.

MATERIALS AND METHODS

Oviductal motility was recorded by the technique of impedance plethysmography (6) in healthy Newzealand White rabbits weighing between 2.5 and 3 *kg*. The implantable encasement containing electrodes for sensing impedance changes across the oviductal segment was made in the A.I.I.M.S. Workshop from teflon sheets. It also housed electrodes required for picking up the electrical activity. The electrodes fixed in the encasement were made of platinum and were secured in the encasement holes with the help of areldite. The line drawings for construction of the encasement are given in Fig. 1.

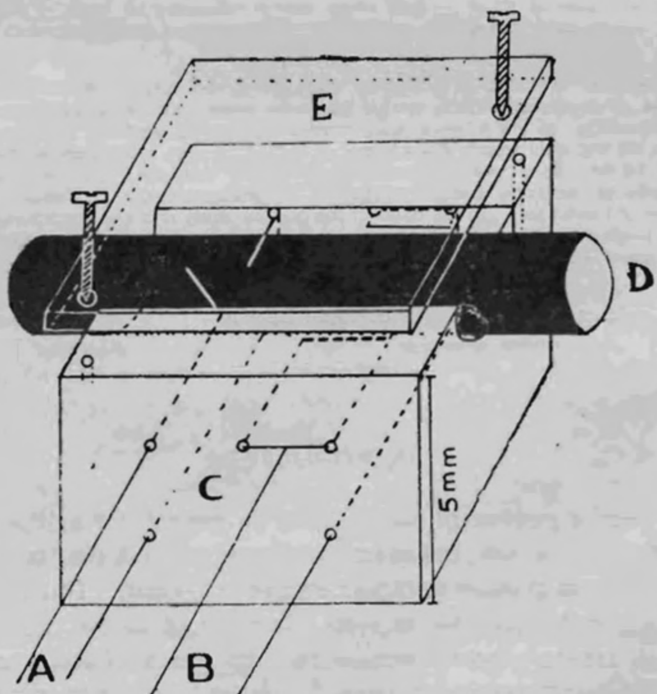

Fig. 1 : The line drawings of an implantable encasement made for impedance plethysmography and electrical activity recording. A - electrode leads for electrical activity, B - leads for impedance recording, C - encasement base, D - isthmus of the oviduct passing through the tunnel in the encasement base. Note the position of impedance and electrical activity sensors. E - the lid which is screwed on the encasement after the isthmus is placed in position.

For permanent implantation, the oviduct was exposed through an incision in the lower abdomen and cleared from the surrounding tissue by gentle dissection with minimal bleeding. The isthmus was identified and placed in the tunnel. The distance between the tunnel wall and the surface of the isthmus was usually kept at not more than 0.5 mm. The lid C was then secured on the encasement. In few earlier trials the whole encasement was fastened to the back of the abdominal wall. In implantations done subsequently the encasement was left free. Leaving the encasement freely floating in the abdomen had the advantage that it would not produce any kinking of the oviduct on account of the freedom of movement thus allowed. The platinum leads were soldered to connecting wires which were colour coded and brought out of abdomen through a stab wound in the posterior wall. These lead wires were then housed in an aluminium receptacle fixed on the surface of the skin just above the wound. Such rabbits with intra-abdominal implants have been living a happy and normal life in the laboratory till they are sacrificed say about 3-4 months after implantation (Fig.2).

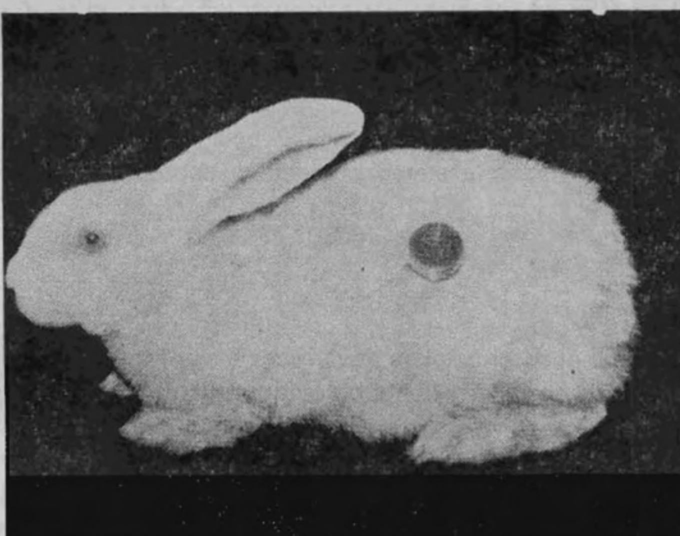

Fig. 2 : The rabbit with the implanted electrodes. The leads of the electrodes are lodged in the aluminium receptacle fixed on the skin. Whenever required, the lid of the receptacle is unscrewed and the leads connected to the polygraph.

Postmortem examination in most cases did not show any adhesions and the oviducts could be easily separated and brought out of the abdomen for further processing for the localization of ova. Similarly the electrode encasement could be easily removed for further implantation in other rabbits. All these procedures were performed under deep surgical anaesthesia (30-40 *mg/kg* sodium nembutal).

The electrodes were connected to different channels of a Grass polygraph through appropriate pre-amplifiers. For plethysmographic impedance recording, the preamplifier was locally fabricated as per Guha, *et al.* (6). This preamplifier also had a dial for direct reading of the changing impedance. The electrical spikes were recorded through a Grass

AC preamplifier. At the time of recording the rabbit was mildly restrained in a specially fabricated restraining box to avoid movement artefacts.

Ovulation was induced by the administration of hCG (i.v. 50 I.U./*kg*). Recording was started 2-3 weeks after the surgical procedures when the wounds had completely healed, and the rabbits had started eating and drinking normally as also got used to the restraining box. Each recording session lasted for one hr. Besides the controls, these sessions were distributed at intervals of 4,8,12,24,36,48,60,72,84,96 and 108 hrs after hCG administration.

The impedance waves were analysed in terms of frequency, amplitude and the area covered by the waves per unit time obtained with the help of a sensitive planimeter. The impedance data as well as the electrical impulses per unit time were charted against time in hours on abscissa.

In experiments conducted for determining the position of ova, the oviducts were cleared by the method of Orsini (9) and the ova positions plotted on diagrammatic blanks after viewing the ducts under a stereozoom microscope.

RESULTS

Basal values

A large number of records taken at various times of the day over a period of weeks established the base level activity in rabbit oviduct which was fairly constant from rabbit to rabbit. The mean values with standard errors of data obtained from nine rabbits with four control records from each rabbit are given in Table I.

TABLE I: Analysis of the basal activity of the isthmus of the rabbit oviduct.

A	Impedance wave	
	(i) amplitude (ohms)	10.12 ± 0.06
	(ii) frequency (per min)	10.24 ± 0.62
	(iii) area (cm^2/30 sec)	5.48 ± 0.18
B.	Electrical spikes (per min)	4.36 ± 0.22

Effect of hCG

Administration of hCG produced a remarkably consistent pattern of changes in the motility. The pattern consisted of the following three phases:—

(1) *Receptive relaxation:* During this phase the contractility of isthmus registered a marked decrease. Both the impedance wave amplitude and the area of waves per unit

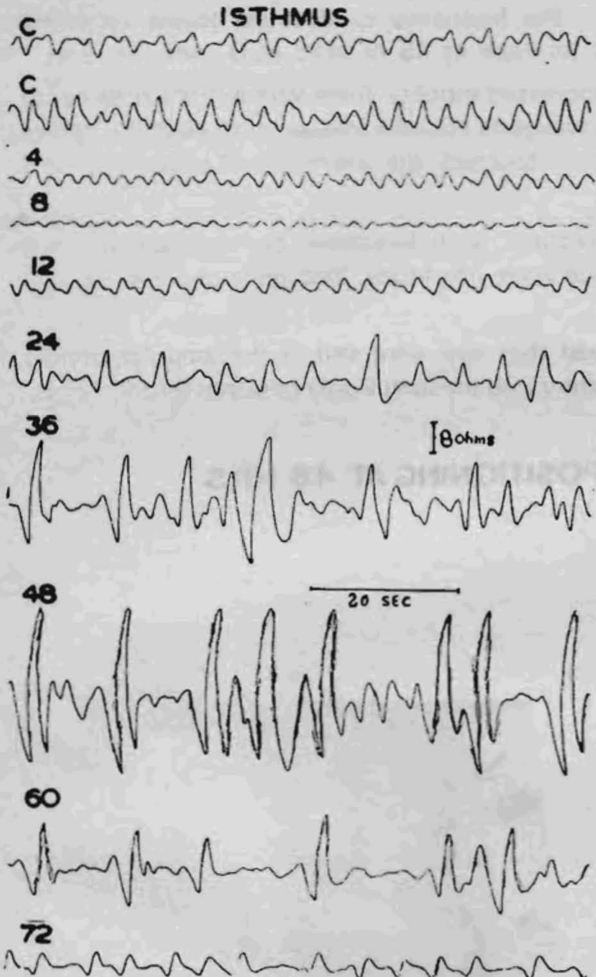

Fig. 3 : Polygraphic tracings of impedance waves. C-Control records. The numbers 4, 8, 12, 24, 36, 48, 60 that and 72 indicate the hrs after hCG injection when these records were taken. Note the motility is decreased at 4, 8 and 12 hr. At 8 hs it is only a ripple of waves. Then on, the motility starts increasing reaching a maxima at 48 hr when the waves are very big, each wave covering a large area. It reaches near control level at 72 hr. This pattern was obtained from all rabbits tested so far.

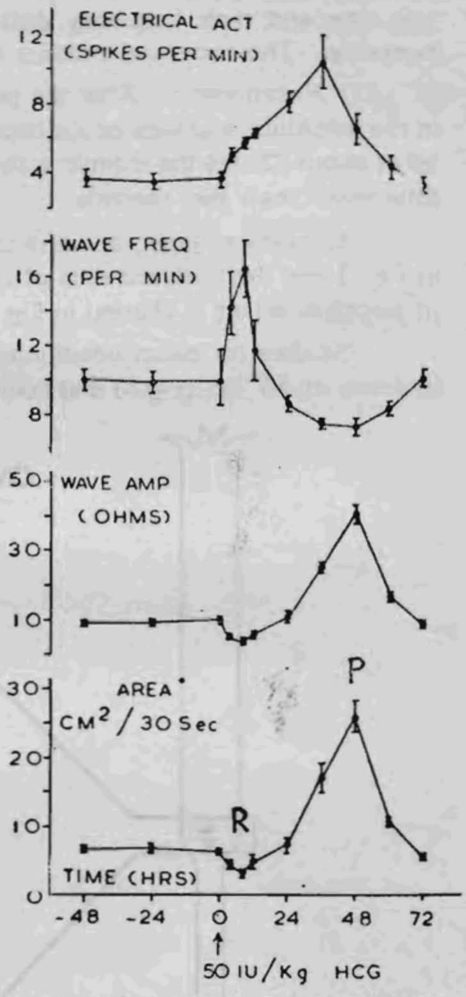

Fig. 4 : The analysed data of impedance waves i.e. wave frequency. wave amplitude and wave area per unit time and electrical spike frequency obtained from six rabbits plotted against time in hrs. The values are mean $\pm$S.D. Note the initial receptive relaxation (R) and later increased motility reaching the peak (P) at 48 hr after hCG administered at O hr.

time were decreased. This was irrespective of changes in wave frequency which increased in most cases. The frequency of electrical spikes was increased but the increase was not statistically significant. This phase of decreased motility started within 4 hrs of hCG administration and lasted for upto 8-12 hrs.

(2) *Increased isthmic motility* : After the initial relaxatory phase the isthmic motility started increasing, the impedance waves now being bigger and covering larger area per unit time and their frequency decreasing. The frequency of electrical spikes increased markedly. The increased motility reached its peak at 48 hr after hCG administration.

(3) *Restitution* : After the peak of increased motility there was a gradual decrease in the amplitude and area of the impedance waves as also the frequency of electrical spikes till at about 72 hrs the isthmic activity almost touched the control level or even stood a little lower than the controls.

Samples of polygraphic records indicating such sequential changes are depicted in Fig. 3 and the analysed data of impedance wave amplitude, frequency and area as also of electrical spikes is charted in Fig. 4.

Studies on ovum positioning showed that ova were still in the ampullo-isthmic junction at 48 hrs (Fig.5) and could seek entry into the uterus only between 60 and 72 hrs.

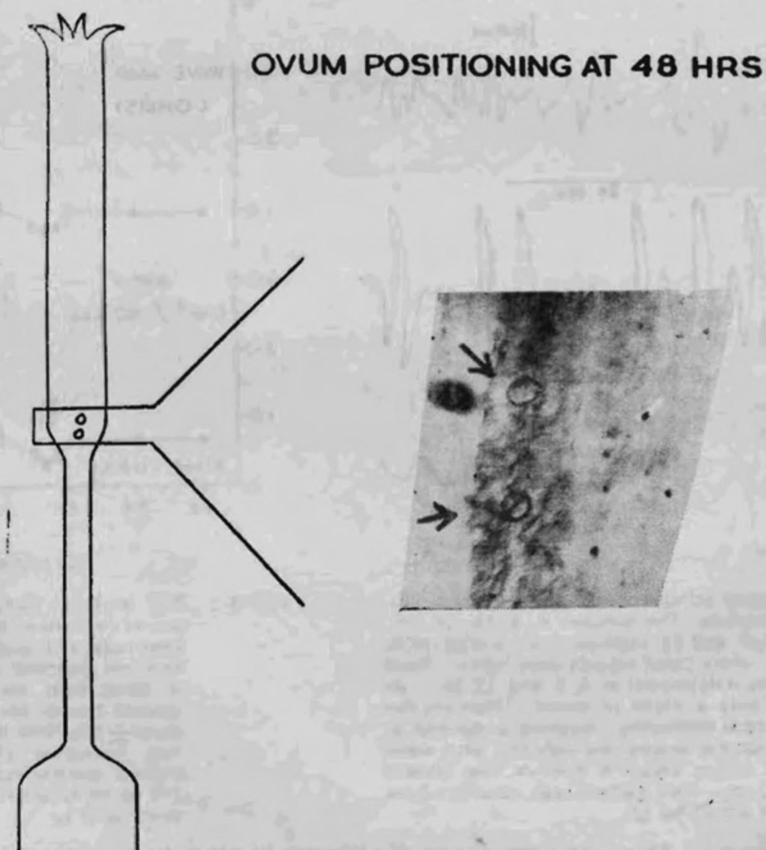

Fig. 5 : Photograph of the ampullo-isthmic junction of the oviduct cleared by benzyl benzoate as per Orsini (9) along with the diagrammatic blank of the oviduct. Note the position of the ova.

These observations were made in six rabbits and were consistently obtained in every rabbit.

DISCUSSION

A recent monograph gives an up-to-date review of literature on oviductal motility and its role in ovum transport (7). From a study of this monograph it becomes evident that recording of motility of the oviduct by many investigators has not produced any predictable correlation between the oviductal contractions and the rate of ovum transport. However, the present study in which the technique of impedance plethysmography has been used to assess the moment to moment diametric changes of the oviduct in the conscious rabbit seems to be the first one to establish the post-ovulatory motility pattern at least with respect to the isthmus of the oviduct and clearly defines the three distinct phases of oviductal motility i.e. (i) receptive relaxation, (ii) increased isthmic motility and (iii) restitution. A post-ovulatory increase in oviductal motility has been reported earlier (1). The present study established that the increase in motility, isthmic motility to be precise, lasts for a period of about 36 hrs after which the restitution sets in. Although never clearly stated it has been tacitly agreed that increased oviductal motility accelerates the ovum transport and decreased motility retards it (2). This does not seem to be probable because in our ovum positioning studies, the ova at about 48 hrs after hCG were observed to be still at ampullo isthmic junction and the isthmic contractions during this particular period were at their peak high. If anything, these contractions should be exercising their force of propulsion towards the ampulla unless, of course the ampullary contractions are more vigorous and of sufficient magnitude to establish a pressure gradient operating from ampulla to isthmus. We have not yet measured the simultaneous impedance changes across the ampullary wall but if morphological characteristics of the ampulla i.e. rather sparse supply of smooth muscle, marked presence of glandular tissue, etc. are any indication the possibility of ampullo-isthmic pressure gradient is highly unlikely. Thus it is suggested that the increased isthmic motility would resist ovum transport along the oviduct and tend to retain the ovum in the ampulla.

Another phenomenon that has come to light in the present study is the sudden depression of isthmic motility on hCG administration, first noticeable at about 4 hr after hCG and lasting 6-8 hr i.e. upto 10-12 hr after hCG. It is only after this initial phase of relaxation that the isthmic motility starts increasing. We have termed this phase of relaxation of isthmus as 'receptive relaxation' for it is during this period that ovulation occurs and the ovum seeks entry into the oviduct. If this relaxation is meant to prepare for the reception of the ovum, than perhaps it should be more applicable to the ampulla which provides the first portal of entry to the ovum. Our preliminary studies in which ampullary activity has been recorded plethymographically do show marked increase in diameter of the ampulla after hCG administration. Receptive relaxation of hollow viscera at other places in the body is known to occur for example the receptive relaxation of gastric fundus is a well-know phenomenon that occurs at the time of swallowing (8).

Further experiments will be required to assess whether these change in motility are due to the direct effect of hCG, or the passage of ovum in the duct or the post-ovulatory changes in the hormonal profile of the animal. Nevertheless, Spilman and Wilks (11) reported a marked increase in plasma progesterone, almost 6-7 times the control level, within 6 hr after hCG/mating. The increase occurred only in those rabbits which ovulated and lasted only upto about 12 hrs after hCG/mating. Thus, there seems to be a good temporal correlation at least between the receptive relaxation and the sudden and spiky release of progesterone.

Many researchers who have been occupying themselves with the pursuit of finding a post-coital contraceptive pill have off and on toyed with the idea of something that could accelerate the ovum transport through changes in oviductal motility leading to a quick ejection of the ovum into the uterus and thence the external environment. Though one is not yet sure if the accelerated ovum transport would be an effective means of contraception it is tempting to hypothesise on the basis of the present study that if it were so then such a substance or pill must characteristically relax the oviductal isthmus so as to reduce the resistance to the passage of ovum through the oviduct.

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