

## Studies on the Origin and the Mode of Propagation of the Contraction Wave in Human Uterus.

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(Received June 8, 1962)

It has been an important problem from a practical standpoint, to know what area of the uterus originates the contraction and how it spreads through the whole organ. Numerous methods have been employed, including the oldest method of direct observation.<sup>1)</sup> Recently many investigations on uterine contractility have been preformed by the multichannel external tokodynamometer<sup>2)</sup> and the measurement of intramyometrial pressure conducted by small balloons implanted in the various regions of the uterine wall.<sup>3)</sup>

In the present experiments, it was attempted to study the myometrial activity by means of recording the action potential. It has been well known that the action potential exhibits the local activity of the myometrium most precisely. However, there are few trustworthy reports concerning the contractility of human uterus performed by recording the action potential, because of its difficulty to obtain the electrical activity of human uterus in situ.

In our previous issue,<sup>4)</sup> it was reported that the action potential, which had similar pattern of spike discharges to that seen in rabbit uterus was obtained in human uterus in situ.

In the present experiments the action potentials were taken simultaneously from three different parts of the human uterus in order to determine the origin and the mode of propagation of the uterine contraction.

### METHODS AND MATERIALS

The recording electrode was Ag-AgCl needle electrode of 0.7 mm. in diameter, the whole surface of which being insulated except the tapered tip. The potential difference was amplified and recorded by electromagnetic oscillograph. The individual of these procedures are described in detail in our previous report.<sup>4)</sup>

The technique of recording action potentials from human uterus in situ;

As shown in Fig. 1, a thin rubber balloon of about 100 ml in capacity was placed in the uterine cavity, which was filled with sterile water and was connected to a manometer to record the internal pressure of the uterine cavity. Three electrodes were inserted through the polyethylene tubes penetrating the rubber balloon and were reached to each special region of the myometrium; first, at the both corners

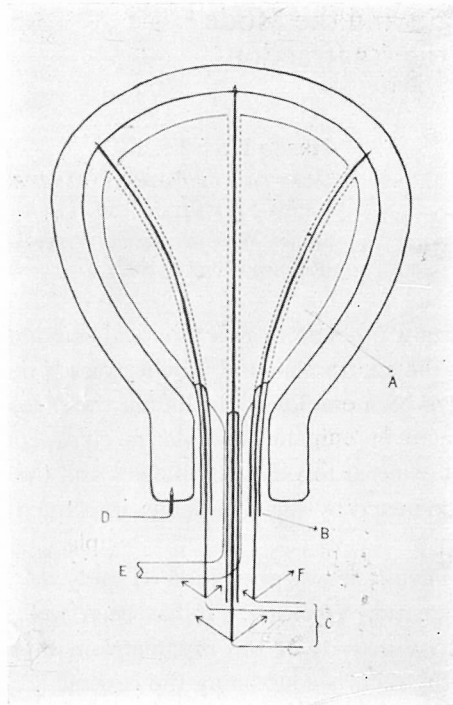


Fig. 1. Method for recording the action potential from puerperal human uterus in situ together with the inner pressure of the uterus.

A: balloon, B: Polyethlen tube, C: different electrode, D: indifferent electrodes, E: tube from the balloon to manometer. The movement of the lever is transmitted to the rotating smoked paper.

and the mid part of the fundus, and then at the fundus, mid part and the lower part along the longitudinal axis of the uterine body. Thus, by obtaining the action potentials by these electrodes from three different regions simultaneously, the origination and the mode of propagation of the contraction waves were explored in the horizontal aspect of the fundus firstly and then in the vertical aspect of the body independently. The distance between each electrode in horizontal aspect of the fundus was 25 to 40 mm when measured after the removal of the balloon refilled with the same amount of water.

#### Materials;

Fifty cases, from 2 to 5 days postpartum human uterus were investigated. When the spontaneous contraction did not occur, several kinds of uterotonics were administered to induce contraction.

## RESULTS

1. Onset of excitation in the horizontal aspect of the fundus.

Fig. 2 shows the typical records. The upper trace was obtained from the left side of uterine cornua, the middle trace from the mid part of fundus and the lower trace from the right side or uterine cornua. Accompanied by the uterine contraction, bursts of spike discharges were recorded which were similar to that obtained in the previous paper.

By measuring the time lag of onset of the action potential in these three parts, the origin of excitation and the mode of its propagation, if any, can be determined. The action potentials shown in Fig. 2 were taken from 5 days post partum uterus contracting with 5 i.u. pituitrin. The action potential appeared first in the mid portion and then after a moment both sides of the fundus were excited almost synchronously although there might be a slight delay between each of them.

Fig. 3 shows the spontaneous activities in the 3 days post partum uterus. The discharges started initially from the right side of fundus being delayed several seconds in both the mid part and the left side where they started almost synchronously. The coordination of the spike groups in every traces was not distinguishable except the first several groups because of their fusion and also some movement artefacts. In these cases the contraction was usually very intense.

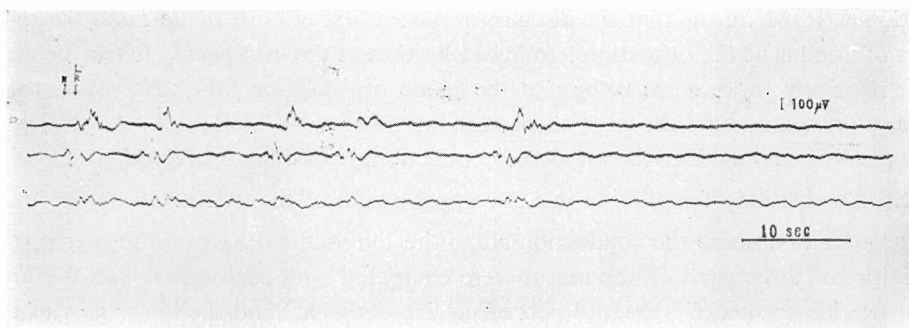


Fig. 2. A typical record obtained from three different parts of the uterine fundus. The upper trace was obtained from the left side of uterine cornua (L), the middle trace from the mid part of fundus (M) and the lower trace from the right side of uterine cornua (R).

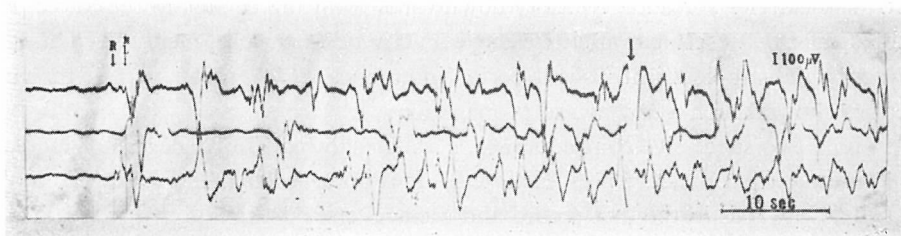


Fig. 3. Spontaneous activities in 3 days post partum uterus. Arrow at the right indicates an onset of acme phase of uterine contraction, judging from the simultaneously recorded intra-uterine pressure curve. (not seen here.)

In table 1, the mode of the conduction determined by the order of commencement of discharges at each electrode site are indicated on 25 contractions recorded from 10 materials.

Table 1. The order of commencement of discharges at each electrode site.  
For the explanation see text.

LMR 7	7
RML 2	2
LRM 1 L (R) M 2	3
RLM 2 RL (M) 2 RL 1	5
M (L) R 1 MLR 2 ML 4	7
MRL 1	1

In this table LMR indicates that the action potential arose in the left side first, then in the mid part and finally in the right side successively. It is presumed in this case that the excitation may have conducted from the left to the right. The abbreviation L(R)M means that the discharges started first at both the left and the right part of fundus at the same time, followed by that at the mid part. It can be seen that relatively more cases belong to the mode of LMR or ML. However, these cases do not command the majority, and many other types are found. Accordingly, it is hardly concluded that any type of conduction predominate over others.

## 2. Conduction of excitation in the vertical aspect of the uterus.

In order to observe the conduction along the longitudinal axis of the uterus, the activities of three parts of the uterus were compared with each other, i.e., the area near uterine cornua (F), the mid part of uterine body (M) and the lower part of the uterus (L). It was usually found that the action potential occurred earlier in the upper portion than in the lower, indicating that the excitation proceeded downwards. These findings seemed to be in agreement with those of other investigators.

Fig. 4 shows the activity occurred 5 min. 30 sec. after administration of ergot extract. The activity spreaded typically downwards from the fundus to the lower part of the uterus. At each led-off site, electrical activities are well synchronized at first, between which an electrically silent period intervenes. The greater part of the contractions showed such a downward propagation.

In Fig. 5 two successive contractions 1, 2 which showed similar degree of increase in the intrauterine pressure are illustrated. It is observed that the contraction propagates downwards in the first record and then reverses its direction upwards in the second record.

Fig. 6 shows the successive four contractions of 3 days post partum uterus. In this case the mid part of the uterus maintains the predominancy consistently; the

activity originating from the middle propagates upwards, while there is no detectable activity in the lower part.

Fig. 7 shows a spontaneous contraction. In this case it takes so long interval between the onset of discharges in the upper and middle part of the uterus that the excitation seems to occur independently in each part of the uterus, although conduction from middle part to lower part might have occurred.

In summing up the 50 contractions of the present experiments, the descending type of contraction was found in 35 cases, the ascending type in 14 cases and the other type in one case, i.e., the contraction wave "usually" propagated downwards though the upward propagation was found in a certain number of cases. In addition a few cases of seemingly localized or short-range conducted contraction were also recorded.

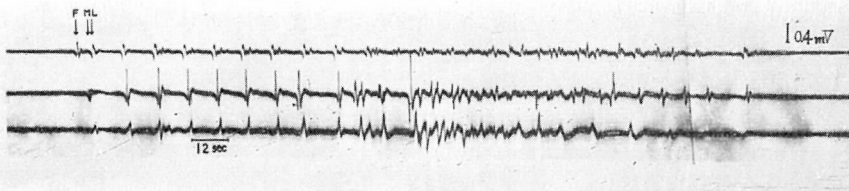


Fig. 4. Three days post partum uterus. The action potentials were recorded which occurred 5 min. 30 sec. after injection of ergot extract. The upper trace was obtained from fundus uterus (F), the middle trace from mid part of the body (M) and the lower trace from lower part of the uterus (L).

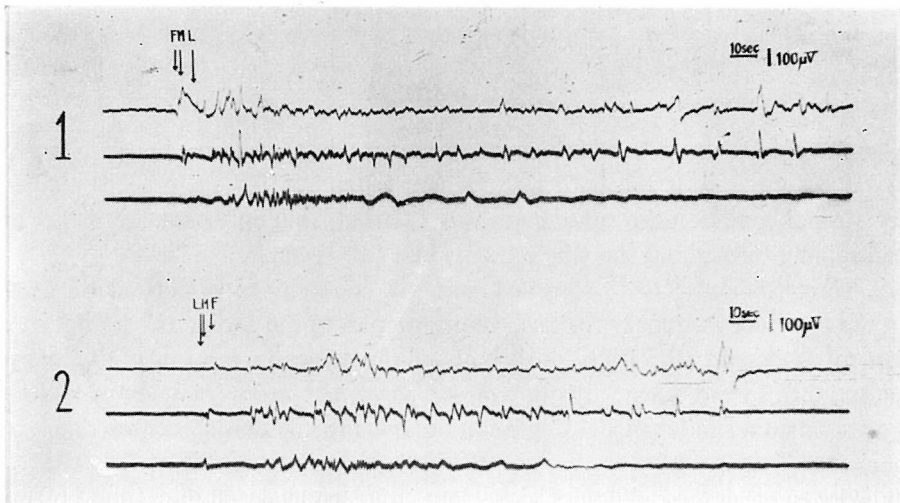


Fig. 5. Two successive spontaneous contractions are illustrated. The three traces are arranged in the same manner as in fig. 4.

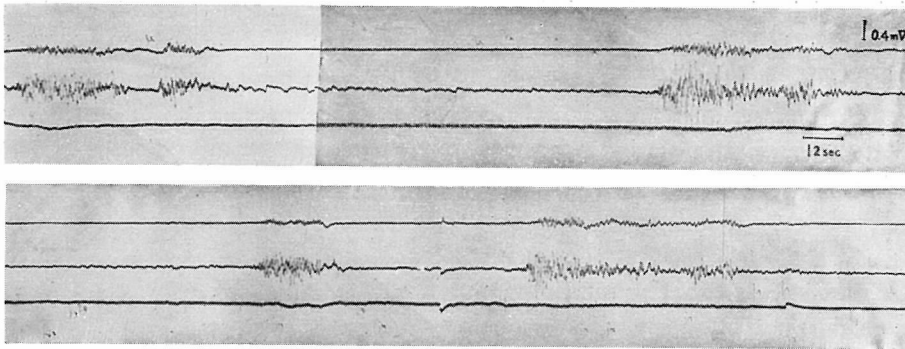


Fig. 6. The successive four contractions induced by the administration of 5 i.u. oxytocin. The upper trace was obtained from fundus uteri, the middle trace from mid part of corpus uteri and the lower trace from lower part of the uterus. Note the mid part of corpus uteri maintains consistently the predominancy.

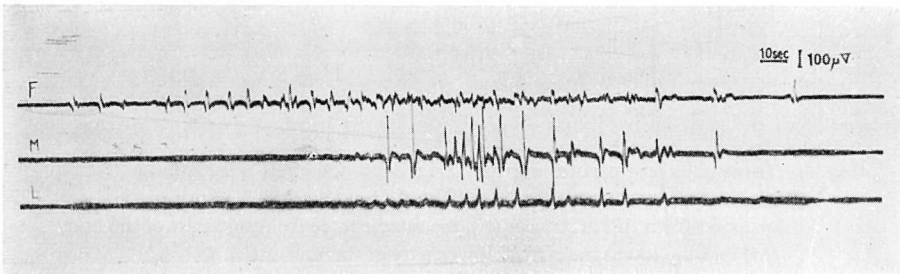


Fig. 7. Spontaneous contraction. F: fundus uteri, M: mid part of corpus, L: lower part of the uterus. For the explanation see text.

## DISCUSSION

Alvarez and Caldeyro-Baracia<sup>3)</sup> reported that the human uterus had two normal pace makers situated at the both sides of uterine end of Fallopian tubes and that under normal condition the contraction wave started from only one pace maker and spread rapidly throughout the whole uterus in a few seconds.

Ivy, Hartman and Koff<sup>5)</sup> observed that the contractions originated bilaterally from the two ever stationary regions, ventro-cranial to the ending of the both Fallopian tubes, spread elliptically until both of them met in the midline with each other and then spread downwards in exposed parturient uterus simplex of monkey. They presumed a similar mode of generation and propagation of contraction wave in human uterus.

In order to bring these different views into unity we recorded the action potential simultaneously from three different parts of the fundus uteri. If the excitation occurs unilaterally, only the LMR or RML type must always be recorded. Moreover,

if it starts only bilaterally, the action in the mid part should always be preceded by the others. However, as is shown in Table 1, all possible patterns could be recorded, indicating that the excitation might originate in mid part of fundus as well as in uterine cornua. Then, it can hardly be concluded that any one part of fundus uteri always takes the priority to the other for inducing the excitation.

It has been previously reported by many investigators that the contraction first occurs in upper part of the uterus and propagates downwards in normal labor. In our experiments during the post partum period, it was also observed the action potential usually appears earlier in the upper portion of the uterus than in the more caudal part, but it should be noted that the ascending propagation such as seen in Fig. 5, (2) or Fig. 6 accounts to 28% of the whole cases.

Though the contraction wave of ascending propagation has been taken as an abnormal one by most investigators, our findings suggest that the excitation can originate in the middle or even lower part as well in physiological condition in human uterus. The role of ascending contraction in the post partum uterus is not yet clear.

Recently Marshall<sup>6)</sup> reported that the pace maker was found both in the ovarian and cervical ends of estrogen-dominated rat uterus.

Although there is structural difference between the primate human uterus and the multiparous animal uterus, the mechanism of the labor in each species seems to be essentially analogous in respect to the uterine contraction delivering a fetus.

Further investigation about the pace maker area and conduction of excitation in parturient uterus of experimental animals is now in progress.

## SUMMARY

1. By recording the action potential simultaneously from three parts of human uterus, the localization of the pace maker is studied.
2. It is found that the excitation can originate from any part of the fundus.
3. In vertical aspect of the uterus, the excitation usually is conducted downwards but in a certain number of cases it is conducted upwards.
4. The fact suggests that the pace maker area may be also found somewhere in the middle or lower part of the uterus as well.

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