Is knowledge of the pattern of electrical activity in the pregnant uterus helpful to our understanding of uterine function? Focus on “Patterns of electrical propagation in the intact pregnant guinea pig uterus” by Lammers et al.

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IT HAS BEEN RECOGNIZED FOR more than 60 years that electrical activity of the myometrium is the fundamental mechanism controlling uterine contractility (1). This observation has been confirmed and reaffirmed in many publications (6, 9, 12). Moreover, electrical spikes, caused by the movement of ions into and out of muscle cells, arranged into bursts, are directly responsible for contractility of the uterus during labor in pregnancy (6, 9, 12, 13). Many of these studies have emphasized the importance of electrical propagation and the contribution this makes is forceful contractions, particularly during term and preterm labor (6, 8). Marshall (12) was the first to establish that the frequency, duration, and strength of uterine contractions are directly proportional to the frequency, duration, and propagation of bursts of electrical activity. Former studies have used a variety of techniques, including micro and extracellular electrodes and other methodology where electrical activity was measured over a small area of the pregnant uterus (9, 12, 13). The recent article by Lammers, et al. (10) describes measurements of electrical activity of the term pregnant guinea pig uterus using 240 extracellular electrodes placed regularly around a large area of the whole uterus. This is an amazing feat considering acquisition, storage, and analyses of signals that occur simultaneously at 240 sites and at 1,000 samples per second for relatively long periods of time. These techniques allow them to evaluate the two-dimensional spread and patterns of propagation of signals and to calculate the velocity of conduction both in the longitudinal and circumferential directions. The studies show that propagation of individual spikes is about 7 cm/s in the longitudinal direction, where the muscle bundles lie parallel to the plane of propagation, as opposed to about 3 cm/s in the circular direction, where muscle is organized at right angles. In addition, the results demonstrate that initial electrical activity occurs more frequently along the ovarian end of the uterus and also along the antimesometrial border. The patterns of propagation are very nicely illustrated in colored images or maps that demonstrate the spatial and temporal conduction patterns of the electrical activity over large areas. Since electrical activity of the myometrium is directly responsible for contractility of the uterus, these studies clearly demonstrate how conduction controls contractility of the uterus.

It was also suggested by clinical studies accomplished by Cadeyro-Barcia et al. (3) many years ago that contractility of the uterus begins in the upper fundal region of the uterus and is conducted toward the cervix. The study conducted by Lammers et al. (10) shows that electrical activity can originate in either the ovarian or cervical end of the uterus and that propagation in either direction (i.e., toward the ovary or toward the cervix) does not affect the velocity. However, the authors indicate that initial activity occurs most often in the ovarian end (corresponding to fundus in humans). Clearly more studies on the origin and directionality of the signals are needed, and some consideration of pacemaker activity might be obtained. The present studies emphasize why propagation is so important for functionality of the contracting uterus during labor. The studies also confirm other work, using electromagnetic field analysis, which corresponds to electrical activity, done by Curtis Lowery and Hari Eswaran and colleagues on humans at the University of Arkansas (4, 5, 14). In this work, large areas of the uterus are analyzed from 151 sites noninvasively with special equipment. The patterns of electrical activity are similar to that described by Lammers et al. (10). Electrical activity of the uterus can also be recorded noninvasively by placing electrodes on the abdominal surface of pregnant patients (2, 11), but no one accomplished a study with many electrodes as done by Lammers et al. (10) in vitro. The basis for propagation and conduction of electrical signals in the uterus has been demonstrated in many structural and functional studies (6, 8) and lies in the cell-to-cell contacts (gap junctions) present between the myometrial cells. In most species, including guinea pigs, the electrical contacts between the cells are known to increase prior to labor and to form the basis for rhythmic and synchronous contractility (6, 8). In the Lammers study (10), uteri were obtained from term animals that presumably have some gap junctions, or they form in vitro during recording as suggested by the authors and shown previously (7). It would be useful to see what the patterns of propagation are like in a uterus from animals that are in the process of delivery where velocity of conduction is known to increase (13).

These studies are exceedingly useful in helping to define the migration of signals over the uterine muscle during pregnancy to control contractility. Propagation, and thereby the recruitment of muscle cells, is the key to forceful labor contractions. Future studies using this approach may include analysis of tissues from delivering animals and uteri compromised by preterm labor or conditions known to delay labor. In addition, future studies could include analysis of various treatments that either stimulate or inhibit contractility.
REFERENCES