The Myth of Fundal Dominance

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In my 2014 book, Dynamic Positions in Birth, I questioned the existence of the 'fundal pacemaker'. The accepted wisdom taught in textbooks is that a fundal pacemaker initiates downward contractions of the uterus during labour. Clinical teaching has been based on this theory since the middle of the last century. Fundal dominance was outlined in the 1948 edition of Reynold's book The Physiology of the Uterus and expanded by Caldeyro Barcia and Reynolds in 1950 (. It is still widely taught. The immediate implication of this is that the fundus will act as a battering ram, propelling the fetus towards the exit.

In the light of recent advances in the measurement of contractions spreading around the uterus, it is time to revisit the theory. Biophysical data do not support the classical theory. These days medical equipment companies are funding research into recording uterine activity in the hope of finding a way to distinguish between established premature labour and threatened early labour. The main focus has been on measuring myometrial activity by electromyography, detecting the electrical activity that drives the muscle contraction of the uterus (EHG, electrohystomyography). Magnetometry has also been used and even MRI. Using the power of computers, researchers are now able to see the site of initiation and calculate the direction of contractions. They see neither a fundal pacemaker nor consistently downward contraction patterns.

Karlsson et al write: "It is possible at times to observe ascendant activation patterns while for the majority of the contractions the activation patterns is descendant. In this situation, the uterine activity begins at the lower electrodes or those situated on one side and then propagates to the other electrodes. Several origins of the activity could often be observed." Lange et al write: [the theory that pacemaker regions is disputed by] "recent EHG studies, showing seemingly random directions of propagation indicating that a contraction can originate in many different areas of the uterus.

Interest in the function of the uterus as a whole organ waned with the advent of safer caesarean section. Once abnormal labour could be 'rescued' by surgery, there was less incentive to understand normal labour and research funding went elsewhere, primarily into pharmacology (prostaglandins and syntocinon) and technology (electronic fetal monitoring (EFM) and ultrasound). There was more clinical interest in recording labour mechanically (to gain an 'objective' view of the progress of labour) than there was in using the information to gain a better understanding of uterine function. The new technology of EFM was welcomed by obstetricians as it appeared to provide an objective record of the progress of labour and it is now seen to be indispensable in the management of abnormal labour and, in some countries, normal labour as well. With hindsight we now know that this was a grave mistake, apart from one study finding a decrease in neonatal seizures in babies of women whose labours were subject to EFM, all that it does is to increase the caesarean section rate (Alfirevic, Devane, Gyte, 2006). EFM tends to immobilise women which, I believe, tends to increase pain by denying women the chance of finding for themselves comfortable positions in labour.

One of the principles underlying EFM came directly from the concept of fundal dominance, i.e. that contractions measured near the fundus reflected uterine activity as a whole and could be compared with the fetal heart rate to give an idea of how the fetus was coping with labour. A late deceleration was deemed to be associated with a struggling fetus whose delivery should be expedited. However, if contractions do not always emanate from the fundus, then a deceleration immediately following a contraction initiated elsewhere could be misinterpreted as 'late' when it actually reflects a normal response. (fig 1, graph of internal and external contractions) Anecdotal reports of babies being born in unexpectedly good condition, with high Apgar scores, following caesarean section, are manifold.

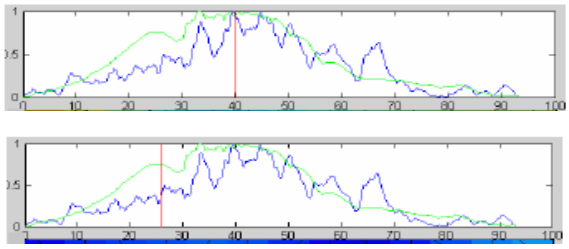

Figure 1 internal and external contractions
Smooth line = external tocograph
Jagged line = electromyograph, total activity from 12 sensors

External tocography is not a reliable measure of uterine activity, the tocograph records only two dimensions of a contraction, the line on the graph

reflects the activity of the uterus over time in just one place (and perhaps not even that, perhaps merely the amount of stretch of the maternal abdomen in one place, see below). Moreover, reading EFM traces is an art rather than a science, the trace is indeed objective evidence of activity in one place, but interpretation is subject to clinical opinion. In some instances, there is no agreement among clinicians as to what constitutes an abnormal trace, even the same clinician can be inconsistent and may interpret the very same CTG trace differently at a later date; test-retest reliability is far from perfect (e.g. Rhöse et al, 2014). Monitoring internal pressure within the uterus with an internal pressure gauge is a more reliable measure of uterine activity but is it justified to submit women to artificial rupture of the membranes (ARM) and an invasive procedure simply because managers require a paper print out of uterine and fetal activity for legal purposes? It is time to explode the theory upon which EFM is based.

History

It may be useful to understand how the fundal dominance theory came to be so widely believed. Back in the middle of the twentieth century, there was considerable interest in normal uterine physiology. An American physiologist, Samuel Reynolds, was considered the authority on the uterus. Roberto Caldeyro Barcia, an obstetrician and physiologist, working in Uruguay was also very interested in uterine activity, coining the concept of Montevideo units which denote the strength of uterine activity. He is also honoured in childbirth activism circles for his quest to humanise birth; he was one of the first to consider the psychological state of the mother in childbirth (Caldeyro Barcia, 1979). Reynolds and Caldero Barcia expended considerable research effort into measuring activity at more than one place on the maternal abdomen. Sometimes up to seven tocodynamometers were placed on the abdomens of women in labour.

They felt sure that they had unravelled part of the mystery of the action of the myometrium, the muscle of the uterus, after they had seen the tracings made by simultaneous tocodynamometry in three or more places on the surface of the uterus and had compared the simultaneous traces. The traces were compelling and the theory fitted the undisputed fact that somehow the uterus must push the fetus towards the cervix. The transducers were so bulky that usually the monitoring had to be done with women lying on their backs.

In fact tocodynamometry was a misnomer, each transducer was a strain gauge and measured the tension of the maternal skin directly above the uterus, not the force generated beneath it. However, the tracings were compelling. They were clearly related to each other and it certainly looked as though contractions travelled downward from the fundus, losing strength as they did so. The external tracings also correlated fairly well with the tracings made by a pressure gauge inserted inside the uterus. Intrauterine pressure (IUP) has long been acknowledged to give a more accurate picture of the strength of contractions but internal monitoring is more invasive and usually requires amniotomy.

The lone voice of a Canadian physician questioned what exactly it was that Reynolds was measuring. Mylks made a latex model of the uterus and, by filling his balloon with varying amounts of water and measuring the strain produced in an different places, was able to demonstrate a similar pattern. Being merely an inert latex balloon, there was no way that any one part of the balloon could be more active than any other part, there could be no fundal dominance in his balloon. Even so, he obtained similar results to Reynolds. He concluded that the downwards travel of contractions was an illusion, the skin above the uterus stretched more at the fundus simply because the uterus rises out of the abdomen during a contraction. Uterine activity stretches the abdomen more at the fundus than at the cervix which is more or less fixed at the lower end by ligaments which suspend it in place within the pelvic girdle.

Caldeyro Barcia was able to show that stronger contractions appeared to be generated when women were in the upright position. From the point of view of physics this is only to be expected; if the fundus moves outwards during a contraction then it will move out further if it is not working against the force of gravity as it is when the woman is lying on her back. Convinced by the improved contraction patterns when women laboured upright, Caldeyro Barcia developed a birthing chair that was in use in the 1980s (and in which I gave birth to my firstborn).

However, the fetal monitor was soon to become more ubiquitous than the birthing chair and although the bed was not a prerequisite for electronic fetal monitoring, women were far more likely to labour on the bed. Clinicians decided that the contraction pattern generated by measuring tension externally towards the top of the abdomen was good enough to relate to fetal heart patterns and much research funding went into fetal monitoring. But the fetal monitor was built on shaky foundations, clinicians have been labouring under the false premise of fundal dominance all these years.

Roger Young is a physiologist and obstetrician working in the USA who is interested in the working of the uterus at the whole organ level. Together with Peter Barendse, he has built a mathematical model which accounts for the whole organ contractions of labour. Young and Barendse (2014) introduce their model thus: "Despite being widely accepted, there is no direct evidence to suggest that organ-level recruitment utilizes a stable pacemaker site or a single propagating action potential. Indeed, there is good evidence to the contrary." Their model suggests that contractions originate at a site of the uterus which is stretched, this sets off a chain reaction in the adjacent network of cells which leads to raised interuterine pressure which stretches the whole internal surface and results in contraction of the whole organ. (Mathematical modelling is necessary since it is not possible to record electromyographic signals over the whole of the uterus, some of it being inaccessible to monitoring equipment.)

The evidence now indicates that labour is not driven by a single pacemaker at the fundus and there is a suspicion that any uterine muscle cell has the capacity to become a pacemaker cell (Devedeux et al 1993, cited in Buhimschi, 2003). If there is no fundal dominance, how is the fetus directed towards the outlet? Consider the physics of an air filled balloon. When the outlet is closed the balloon remains inflated. When the outlet is opened the contents escape through the open end. If there is no fundal pacemaker, what determines which part of the uterus will act as a pacemaker site? The consensus appears to be that contractions are initiated by stretch, but so far the scientific literature has been silent on the cause of the stretch. As one who is immersed in the natural childbirth literature, it seems to me to be obvious that the fetus is the likely candidate. As for the mother, the crux appears to be that the uterus needs to be stretchable in whichever direction the fetus needs to stretch it. The implication is that the uterus needs to be as free as possible inside the mother. The pelvis poses no problem at the front but could pose a problem at the rear if the mother is on her back, hence what is commonly termed 'back labour'. (I found forward leaning positions most comfortable during labour.) A text book on equine reproductive physiology states that during the first stage of labour in a mare the foal is inverted from spine to the mare's belly to spine to spine to prepare for birth (Davies Morel, 1999). The author states that "These contractions [first stage] helped by the movement of the mare and, to a certain extent the foal, result in the repositioning of the foal and the passage into the birth canal." Given the notorious problem of getting a baby with a large head through a pelvis that now has a 90 degree bend, is there a similar mechanism in human birth, ensuring optimal positioning for the start of second stage?

Medical technology has now brought us better ways of measuring contractions and the direction of travel over the uterus during labour. This relatively new technology could be used to investigate the role of maternal and fetal position in labour. Electronic fetal monitoring needs to be revisited in the light of current evidence as to its accuracy.

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