Cervical contractions: the response of the cervix to oxytocic stimulation in the latent phase of labour

KARL S. OLÁH Lecturer, HARRY GEE Senior Lecturer in Obstetrics, JEREMY S. BROWN Research Associate in Obstetrics

Department of Fetal Medicine, Birmingham Maternity Hospital, Birmingham

ABSTRACT
Objective To assess the cervical response to myometrial activity in early labour.

Design Prospective observational study.

Subjects Women requiring oxytocin stimulation in induced and spontaneous labours.

Setting A teaching hospital in Birmingham.

Main outcome measures Simultaneous comparison of the cervical response to myometrial contractions was made on a cycle by cycle basis to deduce the properties of the cervix in early labour.

Results Sixty-seven patients have been monitored, of whom 63 had satisfactory cervimetry data. Thirty (47.6%) women exhibited cervical contractions in response to myometrial activity. This response was only observed at dilatations up to 4 cm. The change in behaviour coincides with the transition from latent to active phases of dilatation. The length of the latent phase of labour was significantly longer in those women who exhibited cervical contractions (P < 0.001), although the active phase was similar in the two groups (P > 0.1). The group without cervical contractions exhibited a greater degree of effacement (P < 0.05) and tended to have more dilated cervices (P < 0.01) than those who showed cervical contractions.

Conclusions It is possible for the cervix to contract in early labour. This response may be the result of incomplete preparation of the cervix for the process of dilatation, and is seen during what is recognised as the latent phase in those women in whom the cervix is un-effaced and undilated. These properties of the cervix may explain the poor results obtained from oxytocin stimulation of labour in the latent phase.

Anatomical and histological studies of the cervix (Danhof 1947, 1954; Hughesdon 1952) have shown that it is predominantly a connective tissue structure with a relatively sparse muscle content. Thus, the cervix has been considered passive in its response to the contractions of the fundus during labour, and the rate of cervical dilatation has been assumed to be directly dependent on myometrial activity. Certain features of labour should lead us to question these assumptions. Friedman (1954, 1955) divided the first stage of labour into latent and active phases. Despite marked differences in the rates of cervical dilatation between these two phases, no concomitant change in uterine activity has been demonstrated. In slowly progressing labour, even when no mechanical problem is identified, improved progress cannot be guaranteed by oxytocin stimulation (Cardozo et al. 1982), and there is a risk of hyperstimulation (Gee & Beazley 1980).

Although the cervix has been considered unimportant in terms of the progress of labour (Friedman 1967), a number of studies have suggested that the cervix contributes resistive forces that influence the progress of labour (Crawford 1975; Arulkumaran et al. 1985; Granström et al. 1991; Lamont et al. 1991). Furthermore, theoretical consideration of the uterus in the first stage of labour shows that cervical compliance could influence the development of uterine wall tension by the myometrium and, in turn, the generation of intrauterine pressure (Gee et al. 1988). A cervix which is noncompliant would contribute to both poor rates of dilatation and the generation of high intrauterine pressure, both of which could eventually contribute to fetal compromise and the need for caesarean section.

To investigate the hypothesis that the cervix could influence the progress of labour and the clinical assessment of uterine activity, the present study was undertaken to characterise the dilatation of the cervix in response to myometrial activity on a contraction cycle by cycle basis.
Subjects and methods

Uterine activity was monitored with a fluid filled, open-ended intra-amniotic catheter. The pressure recording equipment was calibrated against a mercury manometer prior to starting each recording and the guidelines described by Odendall et al. (1976) for the accurate recording of pressure by such systems were followed. The hysteresis in this system is low (less than 0.1%) and non-linearity is less than 1% of full scale. Intrauterine pressure was recorded by a fetal monitor (Hewlett-Packard 8030A) and the analogue signal corresponding to intrauterine pressure was sampled at 5 Hz, converted to digital form and stored onto computer disk.

Cervical dilatation was monitored continuously with the cervimeter described by Richardson et al. (1978) (Surgicraft, Redditch, UK). The instrument comprises a pair of calipers. The ends of the caliper arms fit within the cervical os and pins are mounted near the ends to assist location. During application, the ends (location pins) of the caliper arms are placed as close to the internal os of the cervix as possible. The distance the calipers are opened corresponds to the cervical dilatation, and this is converted to an electrical signal by varying electrical resistance within the circuit with movement of the calipers. This is achieved by the use of strain gauges mounted on the spring in the cervimeter arms. Calibration of the instrument was performed prior to sterilisation using a vernier scale. To ensure that cervical distortion was not caused by the instrument, the force exerted by the calipers at various dilatations was assessed using a Halda 0-500 mN dial gauge. The maximum force exerted by the calipers was 370 mN at 0 cm (1 mN = 0.0981 g), reducing to 50 mN at 10 cm. The cervimeter was applied using an aseptic technique at the time of insertion of the intrauterine pressure catheter. The analogue signal from the cervimeter was sampled at 5 Hz and converted to digital form for computer analysis and storage onto computer disk. All instruments were electrically isolated from the patient.

The signals obtained were analysed on an IBM PS/2 model 70 using LabWindows software (National Instruments, Austin, Texas). The analogue/digital conversion and signal sampling were performed by an MIO-16L interface board (National Instruments, Austin, Texas). Programming within the software package enabled the signals to be displayed in real-time on strip charts, the uterine activity integral, Montevideo units and mean active pressure to be calculated, and the data stored onto disk.

Although the use of an intrauterine pressure catheter in labour is not associated with a significant risk to the patient, and there is no discomfort as a result of insertion, the cervimeter was sometimes difficult to apply and associated with some discomfort on insertion. We therefore limited the study to women who had an indication for intrauterine pressure monitoring (and thus a vaginal examination); thus women were recruited whose labours were induced by artificial rupture of the membranes, and those in whom progress was 2 h or more behind a standard partogram action line (Studd 1973) requiring oxytocin stimulation of labour. Informed consent was given by all women in the study, and prior approval by the local ethical committee had been given. All cervical assessments were performed by one clinician (K.O.), and a formal assessment using a modified Bishop's score was made in each case, scoring 0–2 for each of the parameters cervical dilatation, length, consistency, position and station of the presenting part.

Analysis of the cervicograms was performed retrospectively, and the end of the latent phase was taken as the point at which the active phase was thought to have commenced. Uterine activity was analysed at a point at least one hour after the application of the monitoring instruments, and when a stable level of uterine activity had been attained.

Analysis of results was performed using a Student's t-test for continuous variables; for nonparametric data, a Wilcoxon rank sum test was performed.

Results

Sixty-seven women were monitored, although in four the cervimetry data were of poor quality and uninterpretable. Therefore data from the remaining sixty-three women were analysed. In all cases the behaviour of the cervix at the time of myometrial contractions was seen to change with time. In 30 (47·6%) women, the cervix exhibited cervical contractions during labour (Fig. 1). In the remainder (52·4%), there were no such contractions, there being either no response or the expected dilatation in response to myometrial activity.

Cervical contractions, when present, were observed only during the first 3 to 4 cm dilatation. The amplitude of contractions was generally small, ranging between 0·2 and 0·88 cm (mean 0·38). The majority of cervical contractions were synchronous with the contractions of the corpus, although in three women, cervical contractions showed a delay when compared with the intrauterine pressure waveform (Fig. 2). In addition, on closer analysis, cervical dilatation exhibited a biphasic response (passive dilatation initially during myometrical activity

![Cervical Dilation](image1)

![Intrauterine Pressure](image2)

**Fig. 1.** Cervical contractions occurring with contractions of the uterine corpus.
period where the cervix contracts is characterised by mini-
cervical contractions, there was a demonstrable transition
followed by cervical contraction) in these three (Fig.
All the latter cases were in women induced by artificial
contractions occurring after the peak intra-
uterine pressure. It is evident that the cervix is dilating in
response to contractions initially, but there is obvious
contraction following this response.

followed by cervical contraction) in these three (Fig. 3). All the latter cases were in women induced by artificial rupture of membranes and oxytocin. In those showing cervical contractions, there was a demonstrable transition time, lasting up to 15 min, when no cervical response was seen. The cervix dilated in response to myometrial activity, the change corresponding to the point at which the rate of cervical dilatation increased (i.e. that time at which the active phase of labour is thought to commence). The period where the cervix contracts is characterised by minimal residual dilatation and coincides with the latent phase of Friedman’s cervical dilatation curves. The transition period is followed by more rapid dilatation, and corresponds to the acceleration and active phases.

For the purpose of analysis, the patients have been divided into two groups: those with contracting and those with noncontracting cervices. The general obstetric details of each group are listed in Table 1. The contracting group was significantly older, and this was associated with a tendency for them to be more parous.

The length of the latent phase of labour was significantly longer in those women who exhibited cervical contractions \((P<0.001)\), although the active phase was similar in the two groups \((P>0.1)\). There was no significant difference in the Bishop’s score between those women with cervical contractions compared with those without \((P>0.05)\). However, the group without cervical contractions exhibited a greater degree of effacement \((P<0.05)\) and tended to have more dilated cervices \((P<0.001)\) than those who showed cervical contractions. This is consistent with the observations made on the length of the latent phase in the two groups. The majority of cervices were scored as ‘soft’ in each group (contracting, 77%, noncontracting, 79%), the remainder being of ‘medium consistency’ (contracting 23%, noncontracting 21%). There were no cases where the cervix was considered ‘firm’. Data for overall Bishop’s score, cervical dilatation and cervical length on initial assessment are given in Tables 2 and 3.

All patients were receiving oxytocin, but significant differences in the incidence of cervical contractions were observed according to labour onset (i.e. spontaneous, prostaglandins or amniotomy and oxytocin alone) (Table 4). There is no statistical difference in the incidence of contractions between those starting labour spontaneously and those who received vaginal prostaglandins. This observation may be due to similarities in the physical state of the cervix between women in spontaneous labour and those given prostaglandins, or it could be due to a direct effect on the cervical muscles by the prostaglandin \(E_2\) used (Hillier 1976).

The initial state of the cervix, classified by mode of onset of labour, is shown in Table 3. The mean Bishop’s score in the group whose labours were induced by amniotomy and oxytocin was lower than in those labouring spontaneously \((P<0.05)\). There was no difference between those women whose labours were induced with prostaglandins and those labouring spontaneously \((P>0.05)\). The cervices of the women in the amniotomy group were less effaced than those women labouring...
spontaneously (P<0.001) but not significantly different from those having received prostaglandins (P>0.1). Cervical dilatation when monitoring was commenced was greater in those in spontaneous labour when compared with the amniotomy group (P<0.001) and the prostaglandin group (P<0.001). The two induction groups had similar dilatations (P>0.1).

Mean uterine activity showed no difference between the group of women showing cervical contractions and those without, or between the groups of women who had laboured spontaneously and those induced either with prostaglandins or amniotomy and oxytocin (Table 5).

Discussion

These data show that the cervix has more than a passive function, particularly in early labour when the cervix is still relatively uneffaced and undilated. Contractions of the cervix have been demonstrated in animals (Newton 1934, 1937; Bonnycastle & Ferguson 1941; Adler et al. 1944) and in humans (Karlson 1949; Schill et al. 1951; Mackenzie 1976). Studies in pregnant women have shown that in the first and second trimesters of pregnancy the human cervix can contract in response to oxytocic agents (Schill et al. 1951; Mackenzie 1976) and at term the cervix can contract rhythmically, sometimes independently of activity in the uterine body (Karlson 1949).

Despite these findings, it has long been held that the cervix is a passive structure in pregnancy and labour. Histological demonstration that the cervix is composed predominantly of collagenous connective tissue led to the argument that the effect of its sparse muscle content would be functionally insignificant compared with the amount found in the corpus (Danforth 1947, 1954). This line of thought disregarded the mechanics of the anatomical arrangement of the muscle. The small radius of curvature of the collagen and muscle in the cervix gives it a significant mechanical advantage over the muscle arrangement in the fundus. Hughesdon (1952) and Wendell-Smith (1954) ascribed a distinct architecture to the muscle in the cervix. Hughesdon (1952) described an outer longitudinal muscle (the 'extrinsic muscle of the cervix'), which enhanced the tension transmitted to the outer part of the cervix by the muscle in the fundus.

This process may have importance in effecting effacement. For this to be so the process of effacement needs to be re-evaluated. Because movement of tissue would take place from the outer aspect of the cervix, this would result in thinning of the cervix from the external os upwards leaving the tissue of the upper cervical canal (i.e. in the region of the internal os) to be affected last in the process (Gee 1981; Oláh et al. 1991). This would be in keeping with conventional obstetric teaching that it is the internal os which lends functional integrity to the cervix. Electromyographic recording from the human cervix in labour (Pajntar et al. 1988) has demonstrated functionally independent muscle activity consistent with Hughesdon's anatomical description. The commencement of the active phase is characterised by a change in electromyographic activity of the cervix which may be explained by the removal of the muscle responsible for this activity, and which may be a consequence of the mechanism of effacement described above.

Though these arguments weigh heavily in favour of a muscular basis for the contractions described in this study, other explanations for these events should be considered. Tension imparted to a collagenous trellis-like lattice (Goerttler 1930) could produce passive constriction circumferentially when tension is applied longitudinally by the myometrium. These data show no difference in mean uterine activity between the groups which would reflect such wall tension effects. Alternatively, the lower part of the corpus may lift the head on contraction, thus allowing the cervix to constrict passively by elastic recoil. This has not been demonstrable clinically, and the observation of a biphasic response in the cervix (Fig. 3) would militate against a purely passive explanation. A study of the head to cervix forces in these patients (Gee 1981; Gough et al. 1990), in addition to the cervimetric data presented here, may resolve this issue and would be of considerable interest.

Table 5. Uterine activity data. Values are shown as mean uterine activity integrals (UAI, KPas/min), ± SD in parentheses.

<table>
<thead>
<tr>
<th>Onset of labour</th>
<th>Cervical response</th>
<th>Spontaneous</th>
<th>Prostaglandin</th>
<th>A.R.M. &amp; oxytocin</th>
<th>Overall mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractions</td>
<td>1039.4</td>
<td>1082.7</td>
<td>1174.0</td>
<td>1147.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(293-3)</td>
<td>(160-0)</td>
<td>(231-8)</td>
<td>(234-3)</td>
<td></td>
</tr>
<tr>
<td>No contractions</td>
<td>858.4</td>
<td>1175.2</td>
<td>1069.4</td>
<td>1019.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(113-5)</td>
<td>(325-2)</td>
<td>(237-5)</td>
<td>(254-4)</td>
<td></td>
</tr>
<tr>
<td>Overall mean</td>
<td>901.5</td>
<td>1154.6</td>
<td>1130.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(187-2)</td>
<td>(290-1)</td>
<td>(236-6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Wide ranging clinical implications arise from these findings. Consideration of the generation of intrauterine pressure by the uterus indicates that the cervix has a dual role. Its compliance determines its rate of dilatation and, in addition, modulates uterine wall tension and intrauterine pressure (Gee 1983; Gee et al. 1988; Oláh et al. 1991). Thus a noncompliant cervix predisposes to slow labour progress, and, since it has been shown that higher intrauterine pressures decrease placental perfusion (Borel et al. 1964; Janbu & Neshem 1987), may also contribute indirectly to fetal distress. The data shows that cervical contractions are a feature of the nondilated, uneffaced cervix. Under these circumstances oxytocin, which has little or no direct effect on cervical ripening, would appear more likely to give rise to such problems. Stimulation of myometrial activity under these circumstances would increase stress on the fetus from high intrauterine pressure while at the same time effectively decreasing cervical compliance. The result is prolongation of the latent phase with an erosion of the fetal reserves against hypoxia and acidosis. These predictions are consistent with clinical observations which show that oxytocin stimulation in the latent phase of labour is associated with a high incidence of operative delivery and poor fetal outcome (Cardozo et al. 1982; Gibb et al. 1982). Perhaps a more conservative approach as originally advocated by Friedman (Friedman & Sachtleben 1961) would be more appropriate.

It is essential that active management philosophy is applied appropriately. The clinical difficulty with the implementation of cervicograms is prospectively recognising the entry to the active phase. There have been attempts in the past to represent cervical change graphically prior to active dilatation (e.g. the Inductogram: Beazley & Alderman 1976; Gee & Beazley 1980), but they have not been widely adopted nor do they shed any light on the underlying mechanisms or pathology.

The methods and data presented here offer the prospect of defining latent and active phases in terms of cervical behaviour rather than mere morphology.

In terms of labour management, it is rarely stated explicitly that the prime function of the cervix is to retain the conceptus. It does this in the face of mounting myometrial activity (Caldeyro-Barcia & Poseiro 1959). A mechanism which increases cervical resistance in proportion to myometrial activity would ensure a stable equilibrium. The data presented here show that cervical contractions are associated with a prolongation of the latent phase, but not of the active phase. At first this seems paradoxical. The process of effacement has already been alluded to. The anatomy of the muscle layers in the cervix coupled with differential tension across the wall of the uterus would effectively induce differential movement of notional tissue layers to produce effacement (Gee 1981; Oláh et al. 1991). The result is a gradual redistribution of cervical tissue and, in particular, the muscle in the outer third of the cervix is moved to produce a greater radius of curvature at a higher level in the uterus. This results in a smaller mechanical advantage in addition to there being fewer muscle fibres present. The functional effect of this muscle is thus removed. At some point (which will vary depending on factors, such as parity) the state of the cervical ground substance, dilatation and effacement, the transition or phase of acceleration will be encountered, leading to the active phase where a passive response of the cervix is more likely to occur.

Ripening of the cervix will be important in determining the response of the cervix to myometrial activity (Aspden 1988). Ground substance in a rigid state will hold the collagen fibres together, and the muscle which is inserted into the circumferentially wound collagen skeleton will produce constriction. A fluid ground substance, on the other hand, would permit collagen fibre dispersion (von Mailing et al. 1979) and distraction. The action of the muscle could exaggerate this process and thus aid the process of effacement and subsequent dilatation, but only if the preparation of the cervical ground substance has been adequate. There has been no method to quantify this preparatory process to date. Cervimetry, crude though it is at this stage, offers an ability to recognise the functional capacity of the cervix. It reflects the transition of the cervix from pregnancy mode, where the muscle content of the unripe, uneffaced and undilated cervix is capable of contraction and in so doing will increase resistance to dilatation, to its labour mode where hydration and other changes in the ground substance remove the ability to constrict the cervix from the cervical muscle. Oxytocin will produce vastly differing responses in these two different modes.

Under ideal circumstances at the onset of labour, the increase in myometrial activity coincides with changes in the cervix that will allow dilatation to occur. Under pathological circumstances, however, there may be dislocation in the process. Prolonged latent phase may represent the onset of myometrial activity before the cervix has lost its pregnancy function, which some cases of preterm labour may reflect the premature loss of the pregnancy mode (Oláh & Gee 1992a) which may be facilitated by infection resulting in release of pro-inflammatory cytokines and thus prostaglandins (Oláh & Gee 1992b) or abnormalities in the cervical collagen (Granström et al. 1991; Bowes 1992). The management of labour complicated by a cervix that is uneffaced and less than 3 cm dilatation is debatable. Conservative management has been advocated for prelabour rupture of the membranes, early intervention with oxytocin in such cases leading to an increase in the caesarean section rate (Grant & Keirse 1989). Alternative options include the use of ripening agents such as prostaglandin E₂ (which may have an additional effect of relaxing cervical muscles) or mechanical devices (Atad et al. 1991). It is apparent that oxytocin should be used cautiously in these women, and that in light of data presented here our limits for labour progress in the latent phase should be reviewed.

References
640  K. S. OLÁH ET AL.


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