Effects of oxytocin-induced uterine hyperstimulation during labor on fetal oxygen status and fetal heart rate patterns

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OBJECTIVE: The objective of the study was to evaluate effects of oxytocin-induced hyperstimulation on fetal oxygen saturation and fetal heart rate patterns.

STUDY DESIGN: Uterine activity of 56 women was evaluated retrospectively for hyperstimulation lasting 30 minutes using two definitions: group 1: 5 or more but less than 6 contractions in 10 minutes (n = 102, 30-minute periods); group 2: 6 or more contractions in 10 minutes (n = 56, 30-minute periods). Fetal oxygen saturation and heart rate patterns during each period and the preceding 30 minutes of less than 5 contractions in 10 minutes were compared.

RESULTS: Hyperstimulation was associated with significant oxygen desaturation: (group 1 = 10.68 [20%] decrease from 52.14 to 41.46; P < .001); group 2 = 15.34 [29%] decrease from 52.02 to 36.68; P < .001) and significantly more nonreassuring fetal heart rate characteristics, compared with normal uterine activity.

CONCLUSION: Hyperstimulation is associated with negative effects on fetal status. The more contractions in 30 minutes, the more pronounced the effect.

Key words: electronic fetal monitoring, fetal oxygen saturation/fetal pulse oximetry, fetal safety, labor induction, oxytocin-induced uterine hyperstimulation

Although fetal heart rate monitoring has been the subject of numerous studies over the last 5 decades, assessment of uterine activity as it relates to fetal status has received much less attention. Recently, in a study of uterine activity involving 1433 labors and births, uterine activity that included 5 or more contractions in 10 minutes during the last hour of the first stage of labor or 5.5 or more contractions in 10 minutes over the course of the second stage of labor was significantly associated with a higher incidence of neonatal acidemia (umbilical arterial pH 7.11 or less) at birth when compared with contractions that were less frequent.

Earlier research concerning the effects of uterine contractions on fetal oxygen saturation (FSpO₂) found that FSpO₂ decreased during contractions, reaching the lowest level 92 seconds after the peak of the contraction, with approximately 90 seconds required for FSpO₂ to return to previous levels. When contractions were occurring every 2 minutes or more, recovery of FSpO₂ to previous baseline levels was incomplete. FSpO₂ decreased incrementally after each contraction, and the fetus became hypoxemic, recovering only after oxytocin was discontinued.

Comparable effects of too frequent contractions on fetal cerebral oxygen saturation were noted by other researchers. Contraction intervals of less than 2-3 minutes were associated with a decrease in fetal cerebral oxygen saturation when compared with longer contraction intervals, leading to the conclusion that contractions occurring repeatedly at intervals less than 2-3 minutes were likely to result in progressive fetal cerebral oxygen desaturation.

Frequency of contractions used in the definitions of hyperstimulation discussed in the American College of Obstetricians and Gynecologists (ACOG) practice bulletins has varied from 5 or more contractions in 10 minutes (induction of labor), more than 5 contractions in 10 minutes (dystocia and augmentation of labor), and 6 or more contractions in 10 minutes (intrapartum fetal heart rate monitoring); however, there is minimal evidence concerning the effects of excessive uterine activity on the fetus to guide clinical practice. There are limited data on when and how to treat oxytocin-induced uterine hyperstimula-
tion. Some clinicians believe interventions are not warranted until there are resultant nonreassuring changes in the fetal heart rate (FHR) pattern. We therefore conducted this retrospective study to evaluate the effects of hyperstimulation on fetal oxygen status as measured by FSpO₂ and characteristics of FHR patterns. Interventions used to treat hyperstimulation also were evaluated based on their efficacy in terms of time of hyperstimulation resolution.

We previously reported a prospective study of the effects of common intrauterine resuscitation techniques during the first stage of labor on fetal oxygen status with nulliparous women who were having elective labor induction with oxytocin. This is a secondary analysis of uterine activity, FSpO₂ and FHR patterns using that dataset.

**Materials and Methods**

The effects of uterine activity on FSpO₂ and FHR patterns were retrospectively evaluated in 56 healthy nulliparous women who were admitted for elective labor induction with oxytocin and had consented to participate in the study. Institutional review board approval was obtained from St John’s Mercy Medical Center and Saint Louis University in St Louis, MO. Additional inclusion criteria were a singleton fetus in a vertex presentation and a reassuring FHR pattern at the time of enrollment. Women with medical or obstetrical complications or a maternal condition that could potentially influence maternal SpO₂ (eg, history of smoking, asthma, chronic or acute pulmonary or cardiac disease) and those who did not meet criteria for FSpO₂ sensor insertion were excluded.

The first patients who met eligibility criteria on days selected for research study enrollment were invited to participate. If the first eligible patient declined participation, the next eligible candidate was approached until 1 woman agreed or there were no further eligible candidates that day. Women were not in labor when they were approached about possible study participation or consented. Sixty women were approached for study participation and 56 women agreed to participate.

Continuous electronic fetal monitoring (EFM) was used for all patients, and an FSpO₂ sensor was inserted as soon as clinically feasible (upon rupture of membranes, cervical dilation of at least 2 cm, and fetal station of at least -2) along with an Intran intraterine pressure catheter (Utah Medical Products, Inc, Midvale, UT) and fetal spiral electrode (Kendall-LTP, Chicopee, MA). The EFM model M1350C (Philips Medical Systems, Andover, MA) was used with the OxiFirst FSpO₂ sensor (Nellcor, Inc, Pleasanton, CA). Electronic fetal monitor and FSpO₂ data were continuously collected via the OB TraceVue electronic information system (Philips Medical Systems).

We used 2 definitions of hyperstimulation (group 1: 5 or more but less than 6 contractions in 10 minutes; group 2: 6 or more contractions in 10 minutes) to identify periods of excessive uterine activity. We considered 30 minutes to be clinically relevant, so inclusion criteria required that the excessive uterine activity continued for at least 30 minutes. The preceding 30 minutes of normal uterine activity (less than 5 contractions in 10 minutes) was used as a comparison group. We excluded periods of labor when women were in the supine position and when an intravenous (IV) fluid bolus and maternal oxygen administration were being tested as intrauterine resuscitation techniques in the previous study, as well as the second stage of labor, leaving 522.5 hours (1045 30-minute periods) of labor available for evaluation.

For each of the groups (group 1, group 2, and normal uterine activity), the mean FSpO₂ of the 5 minutes prior to the 30 minutes being evaluated and the mean FSpO₂ during the last 5 minutes of the same 30-minute period were compared using the paired Student t test. Repeated measures analysis of variance (ANOVA) was used to compare the differences in the 5 minutes prior and last 5 minutes means among all 3 groups.

ANOVA was used to compare the percentage of change in the means among the 3 groups as well as the mean FHR and mean dose of oxytocin among groups. The Pearson χ² statistic was used to compare differences in characteristics of FHR patterns (absent or minimal variability; accelerations; and late, variable, prolonged, or recurrent decelerations) among groups. The mean FHR and variability were evaluated in the last 10 minutes of the 30-minute period. If absent or minimal variability was noted any time during the last 10 minutes, it was considered present as long as it continued for at least 10 minutes. The 10-minute period of absent or minimal variability required to meet the criteria for a baseline variability change could extend beyond the 30 minute period of uterine activity under evaluation.

Accelorations and decelerations were evaluated over the entire 30-minute period and were considered present if 1 or more were noted, except for recurrent decelerations that were considered present if they were occurring with 50% or more of contractions in a 20-minute period. In some cases, more than 1 type of deceleration was noted.

The mean number of minutes until resolution of hyperstimulation based on 1 or more interventions was compared using ANOVA. We considered hyperstimulation to be resolved when there were less than 5 contractions in 10 minutes for at least 20 minutes. To measure resolution, we calculated the number of minutes from the time the intervention/s was/were noted in the medical record to the end of the last contraction in the series of contractions that represented hyperstimulation. These criteria were chosen based on the change in uterine activity that could potentially minimize physiologic stress to the fetus.

The Statistical Program for Social Sciences (SPSS 13.0 for Windows; SPSS, Chicago, IL) was used for data analysis. The criteria used to evaluate FHR patterns in this study were based on the definitions from the National Institute of Child Health and Human Development (NICHD) Research Planning Workshop. The investigators independently reviewed the FHR patterns, compared interpretation, and reached consensus based on strict adherence to the NICHD definitions.
Results

There were 102 30-minute periods of labor with 5 or more but less than 6 contractions in 10 minutes (group 1) and 56 30-minute periods with 6 or more contractions in 10 minutes (group 2), representing 15.1% of the total time the laboring women were exposed to intravenous oxytocin. These periods were compared with the preceding 30-minute periods of uterine activity with less than 5 contractions in 10 minutes of groups 1 and 2 (n = 158).

Hyperstimulation was identified and analyzed in 41 of the 56 patients, with 15 patients having no 30-minute periods of hyperstimulation. In group 1, the mean FSpO2 5 minutes prior to the 30 minutes of hyperstimulation was 52.14% and 41.46% in the last 5 minutes of hyperstimulation, representing an absolute decrease of 10.68 and a negative 20% change (P < .001). In group 2, the mean FSpO2 5 minutes prior to the 30 minutes of hyperstimulation was 52.02% and 36.68% in the last 5 minutes of hyperstimulation, representing an absolute decrease of 15.34 and a negative 29% change (P < .001). There was no significant difference (P = .65) in the mean FSpO2 5 minutes prior to the 30 minutes of normal uterine activity (51.29%) and in the last 5 minutes of normal uterine activity (51.12%). The decreases in FSpO2 were significantly different among all groups (P < .001) and between groups 1 and 2 (P < .001); thus, as contraction frequency increased, the effect on FSpO2 was more pronounced. The Figure is a graphic representation of the progressive oxygen desaturation during 30 minutes of hyperstimulation using FSpO2 values plotted every 5 minutes.

Although the dose of oxytocin in all 3 groups was relatively low, there were significant differences (P < .001) among groups based on the mean dose of oxytocin being infused: 6.08 (SD 4.46) mU/min; 9.64 (SD 5.46) mU/min and 12.03 (SD 5.31) mU/min in the normal uterine activity group and groups 1 and 2, respectively.

The characteristics of FHR patterns were compared among the 3 groups, including mean FHR; absent or minimal variability; accelerations; and late, variable, prolonged, or recurrent decelerations (Table). When compared with normal uterine activity, there were no differences in the baseline FHR; however, there were more periods of absent and minimal variability, less accelerations, and more late and recurrent decelerations in the 2 hyperstimulation groups (Table).

Differences in several FHR characteristics also were noted between groups 1 and 2. When compared with group 1, in group 2, there were less accelerations (P = .014) and more recurrent (P = .031) decelerations. There were no significant differences between groups 1 and 2 for absent or minimal variability (P = .063), variable decelerations (P = .554), late decelerations (P = .093), or prolonged decelerations (P = .912). The mean time before changes in variability appeared was 24 minutes in group 1 and 22 minutes in group 2 (P = .081); however, fetal oxygen desaturation was noted in both groups within the first 5 minutes of excessive uterine activity, progressively decreasing over the course of 30 minutes (Figure).

Four types of interventions were used to treat hyperstimulation, including decreasing the rate of oxytocin by half, discontinuing the oxytocin infusion (D/C oxytocin), lateral repositioning, and an IV fluid bolus of approximately 300 mL of lactated Ringer’s solution. In most cases, more than 1 intervention was used. Interventions were able to be identified from the medical record in 148 of the 158 periods of hyperstimulation. Efficacy of interventions to resolve hyperstimulation was compared based on type of intervention/s: D/C oxytocin (n = 35); D/C oxytocin and an IV fluid bolus (n = 69); and D/C oxytocin, an IV fluid bolus, and lateral repositioning (n = 38).

There were only 6 cases of decreasing oxytocin by half (all in group 1), so these cases were not included in the ANOVA used for comparison because of the small number. The mean time for resolution on the basis of decreasing the oxytocin rate by half was 23 minutes in these 6 cases.
### TABLE
Changes in fetal oxygen saturation and fetal heart rate patterns based on frequency of uterine activity

<table>
<thead>
<tr>
<th>FSpO2 and FHR characteristics</th>
<th>Normal, less than 5 contractions in 10 min, n = 158</th>
<th>Group 1, 5 or more but less than 6 contractions in 10 min, n = 102</th>
<th>Group 2, 6 or more contractions in 10 min, n = 56</th>
<th>Level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSpO2</td>
<td>No change</td>
<td>↓ 10.68 (-20%)</td>
<td>↓ 15.34 (-29%)</td>
<td>&lt;.001c</td>
</tr>
<tr>
<td>Mean FHR (beats/min)</td>
<td>135 (± 11.5)</td>
<td>139 (± 10.9)</td>
<td>138 (± 12)</td>
<td>.46b</td>
</tr>
<tr>
<td>Absent variability</td>
<td>0 (0)</td>
<td>2 (1.9)</td>
<td>2 (3.58)</td>
<td>.111c</td>
</tr>
<tr>
<td>Minimal variability</td>
<td>12 (7.6)</td>
<td>11 (10.8)</td>
<td>9 (16.1)</td>
<td>.011c</td>
</tr>
<tr>
<td>Accelerations</td>
<td>136 (86)</td>
<td>79 (77.5)</td>
<td>35 (62.5)</td>
<td>&lt;.001c</td>
</tr>
<tr>
<td>Variable decelerations</td>
<td>28 (17.7)</td>
<td>30 (29.4)</td>
<td>14 (25)</td>
<td>.451c</td>
</tr>
<tr>
<td>Late decelerations</td>
<td>14 (8.9)</td>
<td>16 (15.7)</td>
<td>15 (26.8)</td>
<td>.032c</td>
</tr>
<tr>
<td>Prolonged decelerations</td>
<td>0 (0)</td>
<td>4 (3.9)</td>
<td>2 (3.6)</td>
<td>.085c</td>
</tr>
<tr>
<td>Recurrent decelerations</td>
<td>15 (9.5)</td>
<td>22 (21.6)</td>
<td>21 (37.5)</td>
<td>.002c</td>
</tr>
</tbody>
</table>

Data are presented as mean (percent change), mean (± SD) and n (percent).

a Repeated-measures ANOVA.

b ANOVA.

c Pearson χ².


The majority of women were laboring in an upright or semi-Fowler position. There were significant differences in resolution of the hyperstimulation pattern based on the interventions used. Use of all 3 interventions resolved the hyperstimulation pattern more quickly (6.1 minutes, SD 1.9, SEM 0.31) than 2 interventions (9.8 minutes, SD 3.1, SEM 0.38) or 1 intervention (14.2, SD 2.6, SEM 0.44; P < .001). Resolution time was based on the number of minutes from the time the intervention/s was/were noted in the medical record to the end of the last contraction in the series of contractions that represented hyperstimulation. If calculated instead using the endpoint as the beginning of the first contraction in the series of contractions representing normal uterine activity, the resolution time would have been found to be approximately 2-3 minutes longer.

**Comment**

In this study, hyperstimulation was associated with a negative effect on FSpO2 and characteristics of FHR patterns. These results are consistent with Johnson et al, who found that 20 minutes of hyperstimulation resulted in a rapid fetal oxygen desaturation with an average decrease in FSpO2 of 18% as well as decelerations after each contraction. Crane et al also found that late decelerations and other worrisome FHR changes may occur during excessive uterine activity.

Uterine contractions cause an intermittent decrease or interruption in blood flow to the intervillous space in which oxygen exchange between the mother and fetus occurs. In most healthy fetuses, the physiologic effects of contractions occurring with normal frequency are well tolerated. Crane et al found that hyperstimulation (using the criteria of more than 5 contractions in 10 minutes for 2 consecutive 10 minute periods) occurred in more than 30% of labors induced with oxytocin. If excessive uterine activity causes the intermittent interruption of blood flow to the intervillous space to exceed a critical level, there is risk of fetus hypoxemia. The more time between contractions, the more time there is to maximally perfuse the placenta and deliver oxygen to the fetus.

Potentially adverse effects on the fetus may be avoided by minimizing periods of hyperstimulation and treating it in a timely manner when occurring rather than waiting until the FHR pattern is nonreassuring. In this study, progressive fetal oxygen desaturation began within the first 5 minutes of excessive uterine activity (Figure), well before nonreassuring changes in FHR variability appeared (22-24 minutes). The absolute decrease and the percentage of negative change in FSpO2 after only 30 minutes of hyperstimulation are of potential concern for fetal well-being. Although we were unable to measure the effects on the fetus of hyperstimulation lasting longer than 30 minutes, it seems logical to conclude, on the basis of these data, that progressive fetal oxygen desaturation could potentially continue if hyperstimulation was left untreated.

Treatment of oxytocin-induced uterine hyperstimulation has not been well studied; however, some interventions are often used routinely in clinical practice. Recommended interventions from ACOG for hyperstimulation with a nonreassuring FHR pattern include decreasing or discontinuing the oxytocin infusion, with additional interventions such as lateral repositioning; more intravenous fluids; and, if hyperstimulation persists, terbutaline. When the FHR is persistently nonreassuring, discontinuing the oxytocin infusion is recom-
FSpO₂ of 40% or greater and fetuses with greater increases in FSpO₂ than in the latter group responded with significantly administration on FSpO₂ between fetuses with different effects of maternal oxygen administration.

Two previous studies demonstrated differences.

40%, whereas in group 1, mean FSpO₂ remained above 30% for the entire 30-minute period (Figure). FSpO₂ below 40% may represent low-normal values.

The more nonreassuring FHR changes noted in groups 1 and 2 when compared with the normal uterine activity group may be related to the differences in FSpO₂ values in the last 5 minutes of the 30-minute periods of labor studied (5.12%, 41.46%, and 36.68% during normal uterine activity; 5 or more but less than 6 contractions in 10 minutes; and 6 or more contractions in 10 minutes, respectively), although the mean FSpO₂ remained above 30% in all groups. After 20 minutes of hyperstimulation in group 2, mean FSpO₂ was below 40%, whereas in group 1, mean FSpO₂ remained above 40% for the entire 30-minute period (Figure). FSpO₂ below 40% may represent low-normal values.

Two previous studies demonstrated differences in maternal oxygen administration on FSpO₂ between fetuses with FSpO₂ of 40% or greater and fetuses with FSpO₂ less than 40%. Fetuses in the latter group responded with significantly greater increases in FSpO₂ than in the former group when their mothers were given oxygen.

There are several shortcomings associated with this study. We were limited to a retrospective review because of the obvious inappropriateness of inducing hyperstimulation to prospectively study its effects on the human fetus. The patient sample was relatively small, although it allowed an evaluation of 1045 30-minute potential time periods for hyperstimulation. Even so, only 102 and 56 30-minute periods were identified in groups 1 and 2, respectively.

We were unable to evaluate the effects on the fetus of more than 30 minutes of hyperstimulation because it was usually identified and treated before it progressed beyond this time frame. The data set was originally part of another study for a different objective; however, we felt these data were appropriate for use for this study because healthy women having elective labor induced with oxytocin represent clinical characteristics of contemporary obstetrical practice in which at least some periods of hyperstimulation may often occur, even with excellent care.

We conclude that fetal well-being may be in jeopardy when oxytocin-induced hyperstimulation occurs during labor. Based on our findings and the findings of others, the frequency component of the definition of hyperstimulation as 5 or more contractions in 10 minutes may be more conducive to safe care for the fetus during labor than other commonly used definitions that include more than 5 contractions in 10 minutes or 6 or more contractions in 10 minutes. Retrospective studies with much larger samples are required to evaluate the effects of uterine hyperstimulation on neonatal outcomes.

REFERENCES


