Fetal Health Surveillance in Labour

Abstract

Objective: This guideline defines the standards pertaining to the application and documentation of fetal surveillance in labour that will decrease the incidence of birth asphyxia while maintaining the lowest possible rate of obstetrical intervention. Both high- and low-risk obstetrical populations are considered. It is intended that this guideline could be used by all persons providing intrapartum care in Canada, including nurses, physicians, and midwives.

Options: Consideration has been given to methods of fetal surveillance currently available in Canada, including intermittent auscultation, electronic fetal monitoring (alone and when paired with vibro-acoustic or scalp stimulation and fetal scalp blood sampling), the “admission strip,” computerized heart rate analysis, fetal oxygen saturation monitoring, fetal electrocardiogram analysis, and near-infrared spectroscopy.

Outcomes: Short- and long-term outcomes were considered that may indicate the presence of birth asphyxia. The associated rates of operative or other labour interventions were also considered.

Evidence: A comprehensive review of randomized controlled trials performed from 1995 to date and a search of the literature using Medline and the Cochrane Database of all new studies on fetal surveillance. The level of evidence has been determined using the criteria described by the Canadian Task Force on the Periodic Health Examination.

Recommendations:

Part I: Standard Fetal Surveillance in Labour

1. Women in active labour should receive continuous close support from an appropriately trained professional. One-to-one nursing is recommended. (I-A)

2. Intermittent auscultation following an established protocol of surveillance and response (Figure 1) is the preferred method of fetal surveillance in healthy pregnancies in the active phase of labour. (I-A)

3. Labour induction requires close monitoring of uterine activity and fetal heart rate. (III-B)

4. In the presence of abnormal fetal heart rate characteristics detected by intermittent auscultation and unresponsive to resuscitative measures, increased surveillance by continuous electronic fetal monitoring or fetal scalp sampling or delivery should be instituted. (I-A)

5. Continuous intrapartum electronic fetal monitoring is recommended:
   a) for pregnancies where there is an increased risk of perinatal death, cerebral palsy, or neonatal encephalopathy (III-C)
   b) when oxytocin is being used for augmentation of labour (I-A)
   c) when oxytocin is being used for induction of labour (III-C).

6. With respect to continuous electronic fetal monitoring, all professionals must be familiar with the paper speed used in each case to avoid misinterpretation. The correct time should be recorded on the electronic fetal monitoring record. (III-C)
7. Electronic fetal monitoring records should be inspected and documented every 15 minutes in the active phase of labour and at least every 5 minutes in the second stage of labour. (III-C)

8. The timing of electronic fetal monitoring patterns should be determined in association with uterine contractions. The contraction frequency, duration, intensity, and resting tone should be assessed and documented. Abdominal palpation, a tocodynamometer, or an intrauterine pressure catheter may be used to facilitate the assessment. (III-C)

9. Practitioners should use standard terminology when describing fetal heart rate characteristics of an electronic fetal monitoring record. (III-C)

10. Fetal scalp blood sampling is recommended in association with electronic fetal monitoring patterns that are uninterpretable or non-reassuring, such as sustained minimal or absent variability, uncorrectable late decelerations, increasing fetal tachycardia, and abnormal FHR characteristics on auscultation. (II-3B)

11. The limited knowledge available on the use of labour admission tests warrants further research to establish the usefulness of this screening approach. (III-C)

**Part II: New Technologies for Fetal Surveillance in Labour**

12. The use of computer-based algorithms alone to interpret fetal heart rate patterns is not recommended as a standard of care at the present time. (III-D)

13. Fetal pulse oximetry as an adjunct to electronic fetal heart monitoring in patients with non-reassuring FHR status is not recommended as a standard of care at the present time. (III-D)

14. ST waveform analysis technology is under development but is not recommended as a standard of care at this time. (III-C)

15. Near-infrared spectroscopy as an adjunct to electronic fetal monitoring is currently not recommended as there is insufficient evidence to assess its efficacy in fetal surveillance. (III-D)

16. Further study of fetal pulse oximetry, ST waveform analysis, and near-infrared technology in clinical research settings is encouraged. (III-B)

**Validation:** This guideline was reviewed by the SOGC Clinical Practice Obstetrics Committee, Maternal Fetal Medicine Committee, and ALARM Committee, as well as by the Canadian Medical Protective Association.

**Sponsor:** The Society of Obstetricians and Gynaecologists of Canada.

**TABLE 1**

<table>
<thead>
<tr>
<th>QUALITY OF EVIDENCE ASSESSMENT¹</th>
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<tr>
<td>The quality of evidence reported in these guidelines has been described using the Evaluation of Evidence criteria outlined in the Report of the Canadian Task Force on the Periodic Health Exam.</td>
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<tr>
<td>I: Evidence obtained from at least one properly randomized controlled trial.</td>
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<td>II-1: Evidence from well-designed controlled trials without randomization.</td>
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<td>II-2: Evidence from well-designed cohort (prospective or retrospective) or case-control studies, preferably from more than one centre or research group.</td>
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<td>II-3: Evidence obtained from comparisons between times or places with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of treatment with penicillin in the 1940s) could also be included in this category.</td>
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<td>III: Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees.</td>
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**CLASSIFICATION OF RECOMMENDATIONS**

Recommendations included in these guidelines have been adapted from the ranking method described in the Classification of Recommendations found in the Report of the Canadian Task Force on the Periodic Health Exam.

A. There is good evidence to support the recommendation that the condition be specifically considered in a periodic health examination.

B. There is fair evidence to support the recommendation that the condition be specifically considered in a periodic health examination.

C. There is poor evidence regarding the inclusion or exclusion of the condition in a periodic health examination, but recommendations may be made on other grounds.

D. There is fair evidence to support the recommendation that the condition not be considered in a periodic health examination.

E. There is good evidence to support the recommendation that the condition be excluded from consideration in a periodic health examination.
Food and Drug Administration (FDA) in the United States. Approved software has undergone successful review by these agencies where the data supporting the claims of the companies are analyzed. Ideally, the performance of a new diagnostic test is compared to a gold standard, but there is no recognized gold standard collection of fetal heart rate patterns against which one can test computerized detection algorithms.

Assessing the performance of feature detection for intrapartum use has been reported. The results apply to the particular device under study and should not be generalized to others. Measuring the agreement between a computer and clinical experts is challenging because of the well-described variation in clinical opinion. In one study, the feature detection algorithms were evaluated by four clinicians from varied backgrounds, including an obstetrical nurse, a certified midwife, an obstetrical resident, and a maternal-fetal medicine specialist. One-hour segments of tracings divided into 10-minute windows from the first hour of the active phase of labour from 50 women were analyzed.

Using any one of these experts as a standard, the percentage agreement for accelerations or decelerations varied from 37.7% to 50.5% of the defined accelerations and with 54% to 64.2% of the defined decelerations. The clinicians disagreed on average with 22.4% (range 20.8–23.1%) of the computer alerts. As the performance of these feature detection algorithms has been assessed in only one study, and in that study assessed only in early labour tracings (where the fetal heart rate is more stable than later in labour), and as there is no information regarding the numbers of clinician-identified events that were missed by the computer, this approach, while suggesting potential, is not sufficiently validated to be considered a standard of obstetrical care.

Determining the association between fetal heart rate features and some meaningful clinical outcomes requires an accurate method to detect the features, a large sample of cases in each outcome category that is truly representative of the population, and modelling techniques suited to handling this kind of complex data set. Failure to find associations between fetal heart rate patterns and outcome can be due to limitations in any one or all of these steps, as well as to the inherent limitation of fetal heart rate patterns to predict newborn status.

There are no commercially available computer systems that make interpretations. On a research basis, Keith et al have created a computer system that detects fetal heart rate features and synthesizes one of five possible management suggestions. An extensive analysis comparing the computer system to 17 clinical experts showed good agreement between the computer and the experts, both in terms of the actual recommendation and the time at which it was made.

**RECOMMENDATION**

12. The use of computer-based algorithms alone to interpret fetal heart rate patterns is not recommended as a standard of care at the present time. (III-D)

**FETAL OXYGEN SATURATION MONITORING**

**PHYSIOLOGY**

The oxygen saturation of arterial hemoglobin can be measured using pulse oximetry, whereby the difference in absorption of light by oxyhemoglobin and deoxyhemoglobin, measured at two wavelengths in the red and infrared spectrum, are determined in systole and diastole. In addition to the arterial hemoglobin, light is also absorbed by other nonpulsatile elements, such as venous hemoglobin, tissue, and bone. However, as only the ratio of light absorption between systole and diastole is used, the contribution from other nonpulsatile absorbers is cancelled, so that changes in light intensity only attributable to pulsatile blood elements (primarily arterial hemoglobin) are measured. After obtaining optical signals at systole and diastole for both wavelengths, the normalized ratio of red to near infrared non-absorbed light is used to determine the ratio of oxyhemoglobin to deoxyhemoglobin. The oxygen saturation of arterial hemoglobin is then calculated using a set of empirically derived calibration coefficients.

Pulse oximetry with transmission sensors has now been well validated for the continuous monitoring of arterial oxygen saturation (SpO₂) in both adult and newborn populations and is used routinely in anesthesia and critical care settings. Recently, application of pulse oximetry with use of reflectance sensors, whereby the light-emitting diodes and the photo detector are housed side by side, has been investigated for the monitoring of fetal oxygenation during the intrapartum period. The sensor which has been most studied to date is the FS-14 fetal sensor, which uses light absorption measured at 735 and 890 nm.

**CRITICAL THRESHOLD VALUE FOR FETAL OXYGEN SATURATION**

The fetal oxygen saturation monitor is not an “acidosis detector”; rather, it was designed to indicate whether the fetus is “well oxygenated” or not. The definition of “well oxygenated” is ascribed by the caregiver and is dependent on the agreed-upon “critical threshold.”

A critical threshold appears to exist for a lowering of oxygen saturation in the fetus in relation to the onset of metabolic
acidosi, which would then provide a further means of assessing
the need for delivery in the patient with a non-reassuring
total period of monitoring. An SpO2 of less than 30% for
acidosi, which would then provide a further means of assessing
the need for delivery in the patient with a non-reassuring
fetal heart rate pattern. Study in the ovine fetus, with stepwise
lowering of maternal inspired oxygen over several days, demon-
strated the fetal pH to begin decreasing when preductal arterial
O2 saturation was close to 30%. A second study in the
ovine fetus, with stepwise lowering of oxygenation over several
hours, again showed that fetal pH and base excess values only
began to decrease below an oxygen saturation of 30%. 

In a study of a large tertiary referral hospital population, it was shown that calculated umbilical vein and artery oxygen saturation measured at birth was significantly correlated with pH (r = 0.46) and umbilical artery base excess, albeit
weakly (r = 0.18 to 0.22). Furthermore, the correlations were
better described using cubic rather than linear regression mod-
els, again supporting the concept of a critical threshold or
threshold range for umbilical oxygen saturation values in relation
to measures of acidosis. Further support for the critical
threshold level of 30% comes from a study of fetal pulse oxime-
try in human fetuses compared with scalp blood pH. 

NON-RANDOMIZED CLINICAL STUDIES
In an observational study, Alshimmiri et al. monitored 54
patients labouring at term with non-reassuring FHR patterns,
intraterine growth restriction, or thick meconium, using the
FS-14 fetal oxygen sensor. Fetal SpO2 values showed little over-
all change as monitored through labour and averaged 44% for
the total period of monitoring. An SpO2 ≥ 30% for the last 30 minutes of labour had a positive predictive value of
40% and a negative predictive value of 90% for an umbilical
artery pH less than 7.13 at birth. 

In the French multicentre observational study, Goffinet et al. and Carbone et al. reported on 174 patients labouring
at term with non-reassuring FHR patterns, using the FS-14 fetal oxygen sensor. An SpO2 of less than 30% for the last 30
minutes before fetal scalp sampling had a positive predictive value of 43% and a negative predictive value of 87% for an
umbilical artery pH less than 7.15 at birth, which was similar
to the predictive value of fetal scalp sampling at a threshold of
7.20 for fetal scalp pH. An SpO2 of less than 30% during the
second stage of labour had a positive predictive value of 43%
and a negative predictive value of 88% for an umbilical artery
pH less than 7.15 at birth.

In the German multicentre observational study, Seelbach-
Gobel et al. reported on 400 patients labouring at term with
reassuring and non-reassuring FHR patterns, using the FS-14 fetal oxygen sensor. An SpO2 of less than 30% for more than 15
minutes had a positive predictive value of 58% and a negative
predictive value of 90% for a decline of scalp pH by greater than
0.05 between fetal scalp blood samples, indicating the impor-
tance of duration of low fetal oxygenation, as well as the level of
low oxygenation.

RANDOMIZED CONTROLLED TRIALS
There has only been one randomized controlled trial (RCT) of
fetal oxygen saturation monitoring, the U.S. multicentre RCT, from which Garite et al. reported on 1010 patients labouring
at term with non-reassuring FHR patterns, who received elec-
tronic FHR monitoring alone (control group) or combined
with fetal pulse oximetry (study group), using the FS-14 fetal
oxygen sensor. Study group patients with a fetal SpO2 greater
than 30% were allowed to continue labouring, while the
management of those with a fetal SpO2 less than 30% depend-
ed on the continuing FHR pattern, with the option of fetal
scalp sampling (the same management for control patients).
Study group patients had a 50% reduction in Caesarean section
rate for non-reassuring FHR. However, the overall Caesarean
section rate in the study group was no different from that in the
control group because of an increase in Caesarean section for
dystocia in the study group. Among women undergoing oper-
ative delivery of any kind for non-reassuring fetal status, the
addition of SpO2 was a more accurate predictor (sensitivity and
specificity) of acidosi than EFM alone. There was no difference
in overall neonatal outcome between the two groups. Acido-
sis was defined as cord arterial pH < 7.05 or a cord arterial
base excess ≤ −10.

CONSIDERATIONS AND LIMITATIONS
The accuracy of pulse oximetry in the measurement of arterial
oxygen saturation may be affected by methodologic issues,
including sensor placement and contact, tissue blood volume
and edema, venous pulsation, and variable signal penetration. 
Another variable affecting the utility of the method is the
divide in uterine blood flow in association with hypoxia.
Lastly, on the steep part of the hemoglobin oxygen dis-
sociation curve, small changes in pO2 result in large changes in
oxygenation. Studies in animals indicate that reflectance pulse
oximeters, of the type currently under clinical trial, are more pre-
cise across a range of values than transmission pulse oximeters,
which are calibrated for oxygen saturation greater than 70%.
Low SpO2 values as a measure of fetal oxygenation may be
well tolerated, with no clinically significant increase in anaero-
bic metabolism, depending on the duration of continuing labour
and the ability to initiate compensatory mechanisms. This
ability of the fetus to compensate would account for the low positive
predictive value of 40–50% for SpO2 values less than 30%
and significant acidosi at birth. Conversely, normal fetal SpO2
values may occasionally be associated with significant metabolic
acidemia at birth, as evidenced by the false negative rate of
5–10% in clinical outcome studies. This false reassurance may
be related to a deterioration in fetal oxygenation after removal
of the oxygen sensor or during the delivery process, thus leading
to a degree of metabolic or respiratory acidosis at birth that is
not predicted by SpO2 values through labour. It is also possible
that periodic decreases in fetal oxygenation during uterine
contractions with umbilical cord compression may give rise to a cumulative acidosis over time that is not predicted by SpO2 values, either between or during contractions.18

RECOMMENDATION
13. Fetal pulse oximetry as an adjunct to electronic fetal heart rate monitoring in patients with non-reassuring FHR status is not recommended as a standard of care at the present time. (III-D)

FETAL ELECTROCARDIOGRAM ANALYSIS

Fetal ECG monitoring is a technique used in combination with standard electronic fetal monitoring (EFM). A specialized monitor with proprietary software collects both the standard fetal heart rate and uterine activity signals and the fetal ECG.19 Interpretation is based on the observation that the fetal QRS and T wave change in relation to the metabolic state of the fetal heart.19 By analyzing changes and trends in the ST segment and the T/QRS ratio, in conjunction with a three-level classification of the fetal heart rate patterns, a more precise interpretation regarding the need for intervention can be made.19

Use of this technology requires considerable training, as thresholds for intervention change depending upon the classification of the fetal heart rate patterns (three classes), the T/QRS ratio (two levels), and the shape of the ST segment (three grades).19,20 The impact of this type of monitoring compared to standard electronic fetal monitoring has been evaluated in two prospective randomized clinical trials.19,20 Both randomized clinical trials were conducted in Europe and the data are summarized in Table 2.19,20 Rates of Caesarean section for the indication of non-reassuring fetal status were lowered in the U.K. study only.20 However, total Caesarean section rates were constant.19,20 Instrumental vaginal delivery rates for the indication of non-reassuring fetal status were reduced in the U.K. study20 but this was not statistically significant at the \( P = 0.05 \) level in the Swedish study.19 Statistical significance was achieved when these rates of Caesarean delivery and instrumental vaginal delivery were combined and compared in the two groups.19,20

A reduction in Caesarean rates for a single indication that is not reflected in the total Caesarean rate raises the concern that Caesareans continued to be done and that another indication was recorded by the clinicians. The same concern might be applied to instrumental vaginal delivery rates. Nevertheless, metabolic acidosis was reduced in the Swedish study group,19 total Caesarean rates were not increased, and there were fewer combined interventions for non-reassuring fetal status.20

Use of single parameters such as PR interval or the T/QRS ratio has not been shown to be superior to standard EFM.21,22

<table>
<thead>
<tr>
<th>TABLE 2</th>
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<tr>
<td><strong>CAESAREAN SECTION RATES FOR NON-REASSURING FETAL STATUS</strong>&lt;sup&gt;19,20&lt;/sup&gt;</td>
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<tr>
<td><strong>Number of women</strong></td>
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<td>UK</td>
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<td>Sweden</td>
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<tr>
<td>Sweden*</td>
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<tr>
<td><strong>% Caesarean for the indication of non-reassuring fetal status</strong></td>
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<tr>
<td>UK</td>
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<td>Sweden</td>
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<td>Sweden*</td>
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<td><strong>% Caesarean for all indications</strong></td>
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<td>UK</td>
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<td>Sweden</td>
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<td>Sweden*</td>
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<td><strong>% Instrumental vaginal delivery for the indication of non-reassuring fetal status</strong></td>
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<td>UK</td>
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<td>Sweden</td>
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<td>Sweden*</td>
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<tr>
<td><strong>% Caesareans and instrumental vaginal delivery for the indication of non-reassuring fetal status</strong></td>
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<td>UK</td>
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<td>Sweden</td>
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<tr>
<td><strong>% with cord blood gas evidence of metabolic acidosis pH &lt; 7.05 and base deficit &gt; 12.0 mmol/L</strong></td>
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<td>UK</td>
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<tr>
<td>Sweden</td>
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<td>Sweden*</td>
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* Analysis done after removing data where there was a protocol violation, which means analysis as treated rather than analysis as randomized, which reduces the level of evidence to that of an observational study and has major impact on the proper interpretation of results in this setting.
The concentration of oxyhemoglobin and deoxyhemoglobin within tissue vascular beds can be measured using near-infrared spectroscopy (NIRS). This measurement depends upon the change in absorption of near-infrared light transmitted through the tissue during a change in hemodynamic conditions such as blood flow, blood volume, blood oxygenation, and application of the modified Beer-Lambert law. This technology has been studied as a non-invasive means of monitoring cerebral oxygenation in the newborn and in the fetus during the intrapartum period. In an observational study, Aldrich et al. monitored 41 patients labouring near or at term, using the NIRO-500 spectrophotometer, and demonstrated a significant correlation between fetal cerebral oxygenation values within 30 minutes of delivery and subsequent cord blood gas and pH values at birth. A second observational study compared NIRS to fetal pulse oximetry and found a positive correlation between changes in fetal cerebral oxygenation values and pulse oximetry values. However, study to date in the fetus also indicates continuing technical difficulties with probe positioning and as yet there are no published trials assessing the usefulness of NIRS in the monitoring of fetal condition during labour.

**RECOMMENDATION**

14. ST waveform analysis technology is under development but is not recommended as a standard of care at this time. (III-C)

**NEAR-INFRARED SPECTROSCOPY**

**FUTURE RESEARCH**

The goals for future research in fetal surveillance methodologies should include the study of more specific markers of impending fetal compromise, which could lead to reduced rates of intervention for suspected fetal compromise and lower rates of significant metabolic acidosis at birth.

The evaluation of any method of intrapartum fetal surveillance should address the accuracy of the method, ideally obtained from randomized clinical trials. The accuracy in the real world of clinical practice (effectiveness) as opposed to that in an idealized environment (efficacy) needs to be determined. When new fetal surveillance technologies are approved for use in Canada it would seem advisable to evaluate them in pilot programs under careful supervision prior to their widespread distribution. Such steps should reduce the likelihood of an ineffective technology becoming established as a part of routine practice.

**RECOMMENDATION**

15. Near-infrared spectroscopy as an adjunct to electronic FHR monitoring is currently not recommended, as there is insufficient evidence to assess its efficacy in fetal surveillance. (III-D)

16. Further study of fetal pulse oximetry, ST waveform analysis, and near-infrared technology in clinical research settings is encouraged. (III-B)


**REFERENCES**


