



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th September, 2026

Website: <https://econferencia.com>

PRE-INTERPRETATION QUALITY FAILURES IN INTRAPARTUM CARDIOTOCOGRAPHY: SIGNAL ADEQUACY AND MISSING UTERINE ACTIVITY IN A TERTIARY CENTRE

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Background

Cardiotocography (CTG) is often discussed as a problem of classification: which guideline is used, how fetal heart rate patterns are categorized, and where the threshold for clinical escalation should lie. In practice, however, interpretation may already be compromised before a clinician reaches the classification stage. A technically poor recording can obscure baseline rate, variability or decelerations. Even when the fetal heart rate trace appears readable, interpretation may remain incomplete if uterine activity is not considered. This distinction is important because the timing of a deceleration in relation to a contraction is part of its clinical meaning, not an optional additional detail.

The issue is particularly relevant in tertiary maternity care, where monitoring is frequently performed in pregnancies with high obstetric or perinatal risk and clinical decisions may need to be made rapidly. In such settings, an apparently simple problem of recording quality can influence whether a tracing is judged reassuring, suspicious or concerning enough to alter management. The same limitation also matters for automated interpretation. Digital systems can standardize calculations, but they cannot fully correct for incomplete or clinically insufficient input data.



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Keywords: Cardiotocography; intrapartum fetal monitoring; signal quality; uterine activity; decelerations; quality improvement; clinical decision support; artificial intelligence.

Objective

To evaluate pre-interpretation quality limitations in intrapartum CTG by quantifying technically inadequate recordings and identifying cases in which uterine activity was not adequately considered during assessment.

Design and setting. This was a secondary, quality-focused analysis within a single-centre observational study performed in February 2026 at a tertiary maternal and child health centre in Tashkent, Uzbekistan. During the study period, 363 births were recorded. CTG was performed in 156 cases. The setting was characterized by a high proportion of complex obstetric patients and operative deliveries, reflecting the referral profile of a level III institution rather than the general obstetric population.

Participants and recording criteria. For the main clinical analysis, eligible recordings were obtained during labour in singleton pregnancies at a gestational age of at least 28 weeks. A recording duration of at least 20 minutes was required. CTGs had to have normal or satisfactory technical quality, without persistent loss of signal, and sufficient information to permit structured assessment. Recordings were excluded when signal instability, frequent interruptions or other technical limitations prevented reliable interpretation. The original study also excluded circumstances in which a standardized interpretation would be substantially compromised, including multiple pregnancy and severe technical difficulty in obtaining an adequate tracing.



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Quality variables. The present analysis focused on two distinct levels of quality. The first was recording adequacy: whether the available trace was technically sufficient for structured interpretation. The second was contextual completeness: whether uterine contractions were adequately considered when fetal heart rate changes, particularly decelerations, were interpreted. These two problems were treated separately because they arise at different points in the monitoring pathway. A poor signal is an acquisition problem, whereas omission of uterine activity is an interpretation problem even when the fetal heart rate trace itself is visible.

Statistical approach. The analysis was descriptive. Frequencies and proportions were calculated only where the denominator was clearly defined. The proportion of technically inadequate CTGs was calculated using all 156 recordings initially available for assessment. The source material reported that more than 31 assessments were performed without adequate consideration of uterine contractions; because the exact number and patient-level overlap with technically inadequate recordings were not available, this finding was retained as an absolute count rather than converted into a percentage. No inferential testing, confidence intervals, regression models or causal estimates were produced.

Results

Of 156 intrapartum CTG recordings, 31 were excluded because their quality was insufficient for reliable structured interpretation. The final analyzable dataset therefore comprised 125 recordings. The exclusion rate was 19.9%, meaning that approximately one in five CTGs failed the predefined technical quality threshold before any comparison of interpretation systems could be undertaken.



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This result is clinically important because technical inadequacy can affect several components of CTG assessment simultaneously. Persistent signal loss can make baseline estimation unstable, reduce confidence in apparent variability and fragment decelerations. In this situation, disagreement between clinicians may reflect uncertainty in the source tracing rather than a genuine difference in clinical judgement. A classification label applied to an unreliable recording may therefore create a false sense of precision.

A second quality problem was identified during review of the recordings. In more than 31 cases, CTG assessment had been performed without adequate consideration of uterine contractions. This is not equivalent to poor signal quality. The fetal heart rate channel may be sufficiently clear to invite interpretation, yet the absence or neglect of uterine activity limits the assessment of decelerations because their timing must be interpreted in relation to contractions. Without this temporal relationship, an apparently recognizable deceleration may be misclassified or its clinical relevance may be over- or underestimated.

The findings therefore point to two separate failure points in the CTG pathway. The first occurs before interpretation begins, when the recording itself does not contain sufficiently stable data. The second occurs during interpretation, when available information is not integrated completely. These are different problems and require different corrective measures.

Clinical interpretation. The 19.9% exclusion rate indicates that recording quality was not a marginal issue in this cohort. In a tertiary setting, where CTG is commonly used in patients with increased obstetric risk, loss of interpretable data may be particularly consequential. When the tracing is technically inadequate, repeated recording, correction of transducer position or reassessment



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of the monitoring method may be more clinically appropriate than forcing an interpretation from incomplete data.

The finding related to uterine activity is equally relevant. Decelerations are not defined only by visual shape. Their onset, nadir, recovery and relation to contractions contribute to clinical interpretation. A review process that focuses on the fetal heart rate channel while neglecting the contraction pattern may therefore produce a formally complete but clinically incomplete conclusion. This distinction matters because such errors may persist even when the CTG image itself appears technically acceptable.

Implications for standardization and digital tools. These observations suggest that standardization should begin before the final CTG category is assigned. A structured sequence would first confirm signal adequacy, then verify that fetal and maternal heart rates are not being confused, assess uterine activity, and only after these steps evaluate baseline rate, variability, accelerations and decelerations. The final classification should follow, rather than precede, confirmation that the source data are clinically interpretable.

This approach is also relevant to automated decision support and future artificial-intelligence applications. The source project includes plans to develop a structured database of CTG recordings for automated analysis. Such systems require more than a large number of tracings. They require recordings that are technically clean, consistently annotated and accompanied by the contextual information needed for clinical interpretation. If poor-quality or incomplete recordings enter the training dataset, an algorithm may learn the inconsistencies of the source data rather than the physiology clinicians intend it to recognize.



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Limitations

This analysis has several limitations. It was performed at a single tertiary centre and should not be interpreted as an estimate of CTG quality across all maternity services. The exact number of assessments performed without adequate consideration of contractions was reported as greater than 31 rather than as a precise count. Patient-level linkage between technical quality defects, omission of uterine activity and neonatal outcomes was not available. It was therefore not possible to estimate how often the two quality problems overlapped or whether either was independently associated with an adverse outcome. These limitations are important because they prevent causal conclusions.

Practical quality framework. A practical consequence of these findings is that quality assurance should separate technical adequacy from interpretive completeness. A tracing that cannot support reliable assessment should be identified as such before a diagnostic category is assigned. Conversely, a technically adequate fetal heart rate trace should not be considered fully interpretable if uterine activity is absent or ignored. Treating these as separate checkpoints makes the source of uncertainty explicit and allows targeted corrective action: repeat or improve the recording when acquisition is inadequate, and reconstruct the physiological context when interpretation is incomplete.

Future research. The next stage of this work should prospectively record each quality defect at patient level and link it to the final CTG category, management decision and neonatal outcome. Such a design would allow estimation of the frequency of overlapping defects, comparison of outcomes between technically complete and incomplete recordings, and assessment of whether a structured pre-interpretation checklist improves agreement between clinicians. It would also



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provide a more appropriate foundation for development and external validation of automated CTG models.

Conclusions

Pre-interpretation quality problems were common enough to be clinically relevant in this tertiary-centre cohort. Of 156 initially available intrapartum CTGs, 31 were excluded for insufficient recording quality, corresponding to 19.9%. In addition, more than 31 assessments were performed without adequate consideration of uterine contractions. Together, these findings show that uncertainty in CTG does not begin only at the stage of choosing a classification system.

Improvement strategies should therefore address the entire pathway from signal acquisition to final interpretation. Verification of recording quality and systematic assessment of uterine activity should precede classification. For human interpretation, this may reduce avoidable disagreement caused by incomplete data. For automated systems, it is a prerequisite for building reliable datasets and clinically meaningful decision-support tools.