

https://dspace.org/

Clinical algorithms for management of fetal heart rate abnormalities during labour

K W Cheung; M Bonet; Karlyn Frank-Buchmann; O T Oladapo; George Hofmeyr ...

WILEY-BLACKWELL
https://hdl.handle.net/10539/43732
WOS

Downloaded from a DSpace repository. https://dspace.org/

Check for updates

DOI: 10.1111/1471-0528.16731
www.bjog.org

Review Article

Clinical algorithms for management of fetal heart rate abnormalities during labour

KW Cheung,[a] M Bonet,[b] KA Frank,[c,d] OT Oladapo,[b] GJ Hofmeyr,[e,f] on behalf of the WHO Intrapartum Care Algorithms Working Group*

[a] Department of Obstetrics and Gynaecology, Queen Mary Hospital, The University of Hong Kong, Hong Kong City, Hong Kong SAR, China [b] UNDP/UNFPA/UNICEF/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction, Department of Sexual and Reproductive Health and Research, World Health Organization, Geneva, Switzerland [c] Department of Obstetrics and Gynaecology, University of the Witwatersrand, Johannesburg, South Africa [d] University of Kwa-Zulu Natal, Pietermaritzburg, South Africa [e] Department of Obstetrics and Gynaecology, University of Botswana, Gaborone, Botswana [f] Effective Care Research Unit, University of the Witwatersrand and Water Sisulu University, Mthatha, South Africa
Correspondence: KW Cheung, 6/F, Professorial Block, Queen Mary Hospital, 102 Pokfulam Road, Hong Kong City, Hong Kong SAR, China.
Email: kelvincheung82@hotmail.com

Accepted 14 December 2020. Published Online 12 April 2022.

Objective To construct algorithms with a sequential decision analysis pathway for monitoring of the fetal heart rate and managing fetal heart rate bradycardia, late decelerations and tachycardia during labour.

Population Low-risk pregnant women in labour with singleton cephalic term pregnancies.

Setting Institutional births in low- and middle-income countries.

Search strategy We sought relevant published clinical algorithms, guidelines and randomised trials/reviews by searching the Cochrane Library, PubMed and Google on the terms: "fetal AND heart AND rate AND algorithm AND (labour OR intrapartum)", up to March 2020.

Case scenarios The two scenarios included were fetal heart rate bradycardia or late decelerations (potentially related to uterine rupture, placental abruption, cord prolapse, maternal hypotension, uterine hyperstimulation or unexplained) and fetal heart rate tachycardia (potentially related to maternal hyperthermia, infection, dehydration or unexplained). The algorithms provide pathways for definition, assessment, diagnosis, interventions to correct the abnormalities and ongoing monitoring leading to mode of birth, and linking to other algorithms in the series.

Conclusions The algorithms provide a framework for monitoring and managing fetal heart rate bradycardia, late decelerations and tachycardia during labour. We emphasise the inherent diagnostic inaccuracy of fetal heart rate monitoring, the tendency to over-diagnose fetal compromise, the need to consider fetal heart rate information in the context of other clinical features and the need to engage in informed, shared, family-centred decision-making. We note the need for further research on methods of fetal assessment during labour including clinical fetal arousal testing and the rapid biophysical profile test.

Keywords Algorithm, auscultation, bradycardia, deceleration, Doptone, fetal heart rate, labour, tachycardia.

Tweetable abstract Decision analysis algorithms for fetal bradycardia, late decelerations and tachycardia highlight diagnostic limitations.

Please cite this paper as: Cheung KW, Bonet M, Frank KA, Oladapo OT, Hofmeyr GJ; the WHO Intrapartum Care Algorithms Working Group. Clinical algorithms for management of fetal heart rate abnormalities during labour. BJOG 2024; 131(S2):102–111.

Introduction

Health care during pregnancy is unique in that two individuals need to be cared for interdependently. Occasionally, the best interests of the mother and baby may be discordant. For example, caesarean section in the interest of the baby for suspected fetal compromise places the mother at increased risk.[1] Clinical decision-making needs to balance the risks for both mother and baby, based on the best available evidence, available resources and the preferences of the mother.

During low-risk labour, the World Health Organization (WHO) recommends intermittent assessment of the fetal heart rate (FHR).[2] The FHR may be assessed by

*A list of WHO Intrapartum Care Algorithms Working Group members can be found in the Appendix.

© 2022 John Wiley & Sons Ltd.

auscultation or with a hand-held Doppler device.[3] A normal FHR is usually defined as a baseline between 110 and 160 beats per minute (bpm), with no decelerations.[4] Abnormal patterns include persistence of bradycardia (<100 bpm), tachycardia (>180 bpm) and recurrent prolonged 'late' decelerations following uterine contractions. 'Non-reassuring' patterns, which are neither normal nor clearly abnormal, are a common cause for concern because some may resolve spontaneously while others may be an indication of pending fetal compromise. Non-reassuring features include the following: baseline of 100–109 bpm or 161–180 bpm, variability of less than 5 bpm for 30–50 minutes or more than 25 bpm for 15–25 minutes, variable decelerations with various durations and frequencies. Early, variable and late decelerations are defined by the shapes and their temporal relation to the uterine contractions. Late decelerations are thought to be related to fetal hypoxia due to reduced uteroplacental blood flow during uterine contractions. Early and variable decelerations are thought to be fetal reflex responses unrelated to hypoxia and their significance is controversial.[5]

Continuous cardiotocography in low-risk labours increases caesarean section rates without evidence of clinical improvement for the baby.[6,7] High-technology methods such as fetal electrocardiographic wave-form analysis[8,9] and fetal pulse oximetry[10] have not yet impacted clinical care, and may not be widely available in the near future. Fetal scalp blood analysis is not widely available and may be associated with the risk of mother-to-child HIV transmission in untreated mothers.[11] Meconium passage is a poor indicator of fetal wellbeing. It may be precipitated by mechanisms other than fetal compromise, and is related to fetal maturity. It may be caused by a direct effect of smooth muscle stimulants such as prostaglandins or herbal medication on fetal bowel.[12–14] Meconium-stained amniotic fluid is discussed in another paper in this series.[15] In this article, we present labour algorithms for identifying, diagnosing, managing and monitoring deviations from normal observations of the FHR. We emphasise the need to interpret the FHR findings in the context of a holistic evaluation of clinical features such as the mother's condition, resilience and preferences, uterine contractions, labour progress and signs of cephalopelvic disproportion.

Methods

This work is part of a project commissioned by WHO, for the management of uneventful and complicated labours, to complement WHO intrapartum care guidelines and facilitate the development of electronic evidence-based, decision-support tools by stakeholders, to improve labour outcomes in low-resource settings.[16]

We developed algorithms for two case scenarios, based on findings of a review on FHR abnormalities, identification of the most common deviations, severity of related complications or clinical outcomes and discussion with the WHO Intrapartum Care Algorithms Working Group. These were as follows: fetal bradycardia or late decelerations (Figure 1); and fetal tachycardia (Figure 2). A detailed description of the methodology used for the development of the algorithms is provided elsewhere.[17]

Search strategy

We searched PubMed and Google for previous relevant algorithms on the terms: 'fetal AND heart AND rate AND algorithm AND (labour OR intrapartum)'. We also searched for national/international/institutional guidelines, randomised trials and reviews relevant to fetal monitoring in labour. We searched the Cochrane Library on the terms 'fetal AND heart AND rate AND (labour OR intrapartum)'; and PubMed using the same search terms in November 2018. We updated the search on 20 March 2020 with a PubMed search on the terms 'fetal AND heart AND rate AND (labour OR intrapartum) AND (review OR trial) AND random'. We did not use date or language restrictions.

The literature review was guided by the hierarchy of evidence and prioritised WHO guidelines followed by other international or national guidelines using GRADE methodology. In the absence of guidelines on a case scenario, a combination of existing studies and expert opinion was used to determine key points for consideration in the algorithm. The highest level of evidence found was used to support the decisions along the management pathway, in the order of up-to-date systematic review (with meta-analyses), up-to-date systematic review (without meta-analyses), any available systematic review, validated decision rules, randomised controlled trials, non-randomised controlled trials, observational studies and consensus documents. Two reviewers (OTO and MB) screened the title and the abstract, extending manual searching through the reference lists of relevant articles and extracted the recommendations and supporting evidences into an EXCEL file independently. Any inconsistencies were resolved by a third reviewer (GJH).

Population and setting

The algorithms were developed to cover the assessment and management of pregnant women with singleton, term pregnancies considered to be at low risk of developing complications at admission to the birthing facility, with the diagnosis of active labour, regardless of stage of labour, until childbirth. Health facilities in low- and middle-income countries were the priority. However, the algorithms are applicable to any healthcare setting, and possible adaptations that may be required were acknowledged. The

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

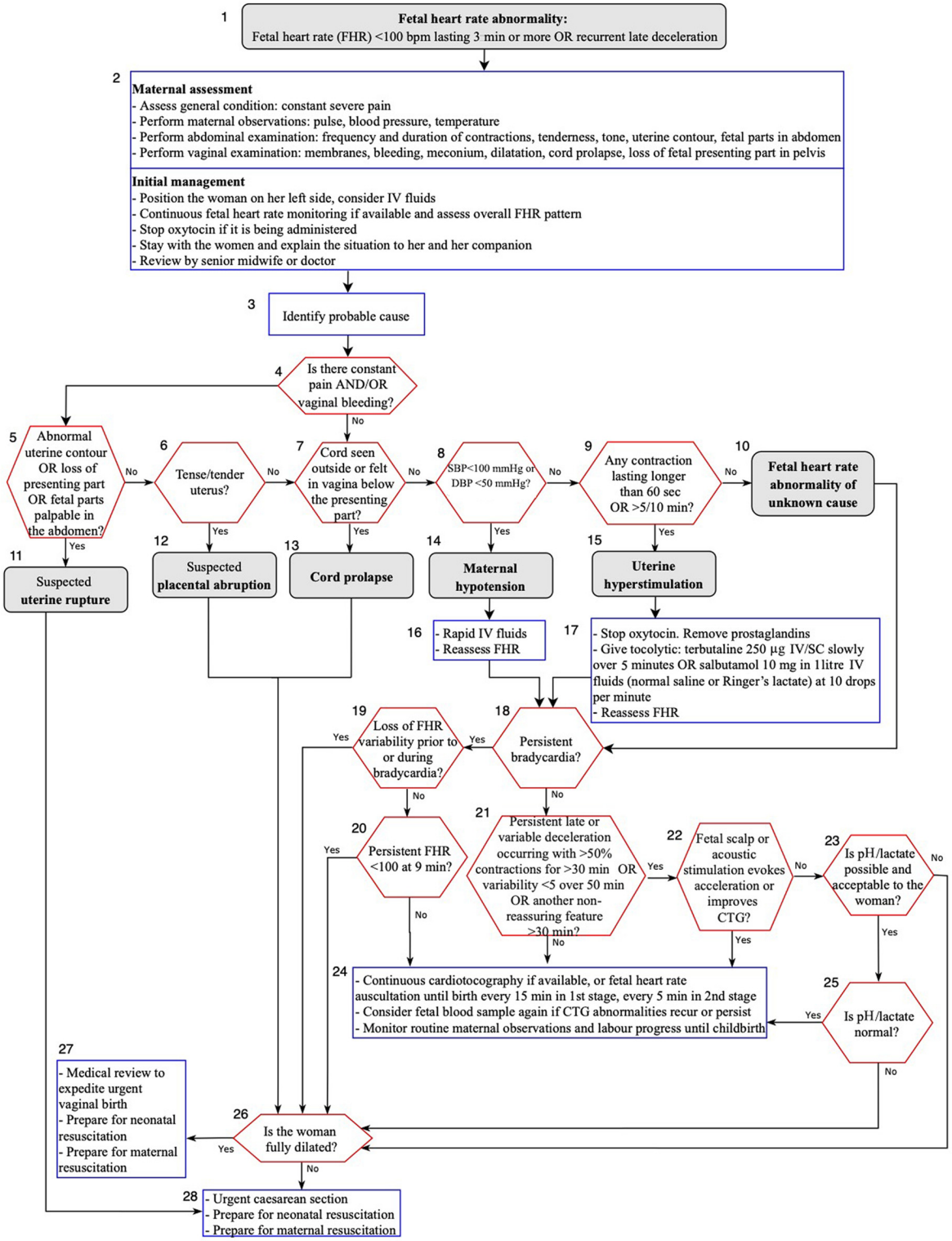


Figure 1. Algorithm A. Fetal heart rate bradycardia or late decelerations.

target users for these algorithms are skilled health personnel providing care during childbirth working alone or as part of teams, particularly midwives, non-specialised clinicians (i.e. clinicians without specialist training in obstetrics but who also provide care for women in labour) and specialists.

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

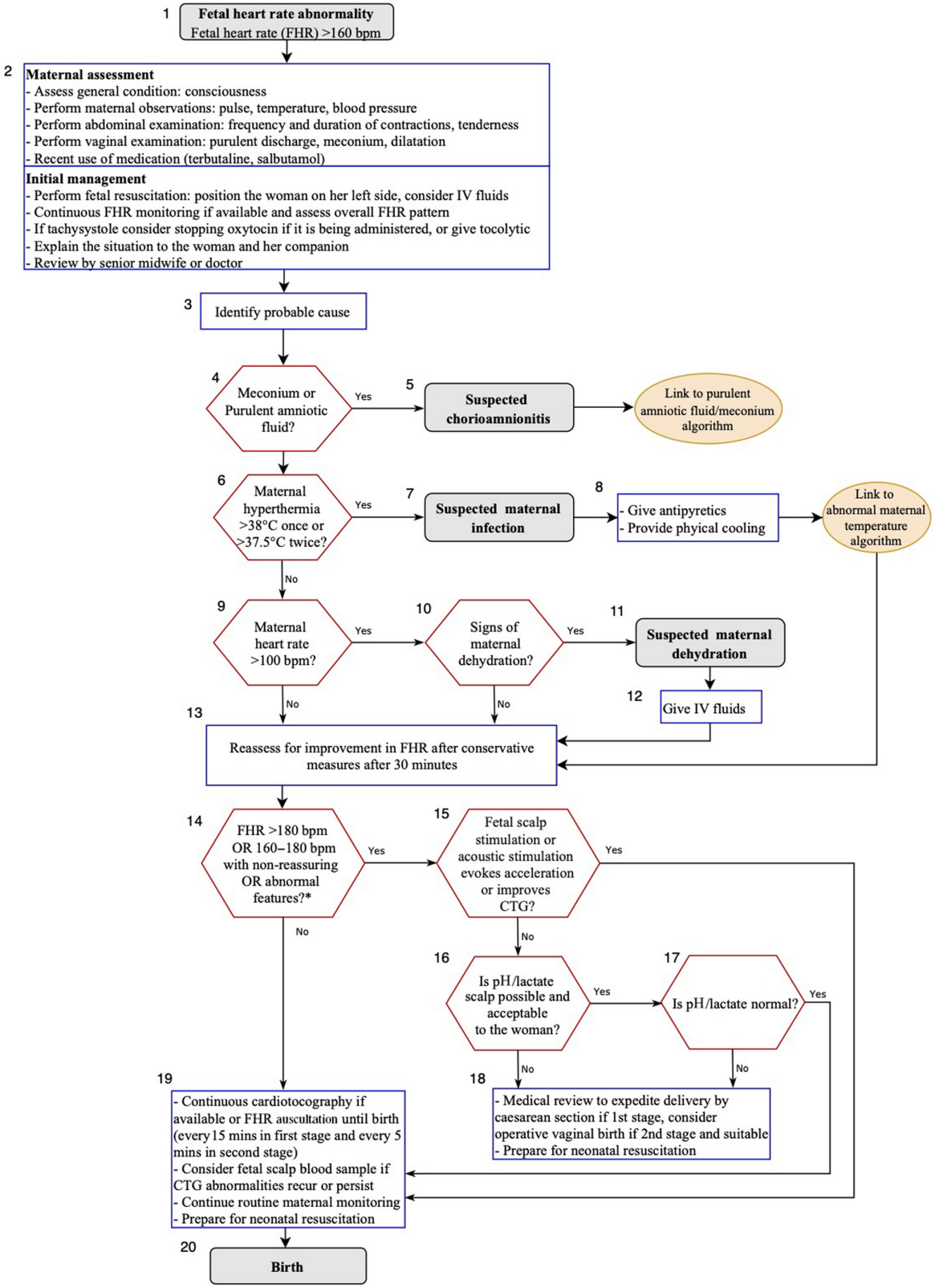


Figure 2. Algorithm B. Fetal heart rate tachycardia.

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Algorithm development

Algorithms were developed through an iterative process using standardised guidance, which included evidence hierarchy, expert consensus and peer review.

After collating the evidence, a selection process for inclusion of the evidence in the algorithm took place. Selection was based on relevance of the evidence to the key decision points and severity of the condition targeted by an intervention. The selection also accounted for the strength of evidence and applicability and feasibility in a low- and middle-income countries context. If there were inconsistencies among guidelines, the most up-to-date guidelines and evidence were reviewed and used to inform consultation with experts. A list of inconsistencies was discussed at the WHO Technical Working Group meeting and a consensus was reached on evidence for the algorithm.

DRAW.IO, an open source diagramming software, was used to construct the algorithm in a flowchart format. The online software facilitated remote working by the WHO Technical Working Group. The algorithm was composed of standardised but variable shaped boxes, representing a clinical state (rounded rectangle), a decision point (hexagon), an action task (rectangle), or a link to a different algorithm (oval). Each box was numbered and joined to other boxes by arrows, to orientate the reader to the direction of flow. The numbers also corresponded to a table of evidence, showing the evidence source for the action and decision points. The algorithms underwent internal peer review by the WHO Intrapartum Care Algorithms Working Group and revisions were made where needed.

We validated the decision pathways by identifying available evidence sources (systematic reviews, meta-analyses, clinical practice guidelines or relevant single studies) and selecting the highest level of evidence. We extracted recommendations and supporting evidence that apply to each case scenario: what observations would warrant a clinical suspicion of the case scenario; what observations define or are characteristics of the case scenario; what differential diagnoses could the observations indicate; what treatment/intervention options exist to slow the progression or correct the deviation back to normal; what observations or assessments are needed to monitor clinical progression of the scenario; and women's views and preferences. Where no guideline existed, we used an evidence hierarchical approach.

Results

Search results

The flowchart of the literature searches is shown in Figure S1.

We identified six guidelines or guidance documents. WHO Managing complications in pregnancy and childbirth,[18] WHO pregnancy, childbirth, postpartum, and newborn care,[19] UK National Institute for Clinical Excellence,[20] Institute for Clinical Systems Improvement,[21] National Clinical Guideline for Intrapartum Fetal Heart Rate Monitoring: Ireland[22] and WHO recommendations: intrapartum care for a positive childbirth experience.[2]

The guidelines were incorporated into the algorithms as indicated in Table S1.

The Cochrane Library search yielded 55 Cochrane reviews and 727 trials. We screened the 55 review titles and abstracts and selected 13 for consideration for inclusion.[6,8,10,23–32] We identified 25 trials not included in the above reviews, and selected nine for potential inclusion.[33–41] The PubMed searches identified 12 relevant non-Cochrane systematic reviews and trials.[42–53]

We identified three previously published algorithms: the California Maternal Quality Care Collaborative,[54] based on the paper of Clark et al.;[55] and FHR tracing and notification guidelines and Kaiser Permanente Vallejo Medical Center suggested an algorithm for the management of variant intrapartum FHR tracings (≥32 weeks estimated gestational age) chart.[56]

Fetal bradycardia or late decelerations

We combined fetal bradycardia with late FHR decelerations because the initial approach to these two abnormalities was similar in the algorithm (Figure 1 and Table S2).

Condition

Fetal bradycardia was defined as FHR less than 100 bpm lasting for 3 minutes or more.

Late decelerations were defined as a gradual slowing of the FHR with onset more than 20 seconds after the onset of uterine contractions; the onset, nadir and return follow after the onset, peak and return of uterine contractions; and are U-shaped in morphology. The UK National Institute for Clinical Excellence defined a non-reassuring FHR pattern as one with late decelerations occurring in over 50% of contractions for less than 30 minutes and an abnormal FHR pattern as late decelerations lasting for 30 minutes or more.[20]

These conditions may be picked up either by intermittent auscultation or continuous electronic fetal monitoring where appropriate.

Assessment and treatment

Fetal bradycardia or recurrent late decelerations occurring in over 50% of contractions should trigger a rapid comprehensive maternal and labour assessment to differentiate reversible from irreversible and unknown causes and guide the decision on further management and mode of delivery and its urgency if necessary.

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Initial management includes repositioning the woman on her left side and stopping any oxytocic agent. Maternal hypotension and uterine hyperstimulation are potentially correctable causes of fetal bradycardia/late decelerations in which intravenous rehydration and acute tocolytics usually suffice, respectively, and the clinicians should observe a gradual recovery of the FHR pattern.

A quick maternal survey will usually reveal the obvious irreversible causes of uterine rupture, placental abruption and cord prolapse, which require prompt maternal resuscitation and delivery.[47] Abnormal uterine contour, loss of presenting part and fetal parts palpable in the abdomen, particularly in women with previous uterine scar, are suggestive of uterine rupture whereas persistent tender uterus with or without vaginal bleeding could indicate placental abruption. Vaginal examination could identify umbilical cord prolapse and assess the progress of labour to decide the best mode of delivery within the clinical context.

For persistent prolonged bradycardia despite conservative management, the loss of FHR variability before or during the bradycardia should prompt the preparation of an operative delivery because these FHR patterns are associated with fetal decompensation and significant acidaemia.[48–50] A longer period of observation could be allowed if FHR variability is retained and the heart rate recovers gradually. The time limit to observe the response for conservative management is ill-defined and the attending clinicians should also take into consideration the local logistics to arrange a speedy delivery. Observation for 9 minutes may be adopted because 95% will recover by 9 minutes.[50,51] A good practice is to involve relevant personnel and begin preparation early even before the decision for delivery. More research is needed on the clinical observation that persistent severe bradycardia below 80 bpm with ultrasound showing twitching of fetal heart muscle rather than contraction is associated with a negligible chance of survival.

For late decelerations that are persistent despite initial resuscitative measures and are not due to underlying irreversible causes, the published criteria for significant features of decelerations do not have robust evidence. Normal FHR variability usually indicates low risk of fetal hypoxia.[50] Progressive loss of FHR variability or worsening late decelerations (deeper and wider decelerations) increase the chance of fetal acidaemia and require further intervention.[51] Where late decelerations are frequent and persist beyond 30 minutes, further interventions are recommended to confirm fetal wellbeing.[20] Although the diagnostic accuracy of fetal scalp or acoustic stimulation needs further evaluation, this non-invasive initial approach could be used to assess the fetal response, otherwise scalp blood pH/lactate level could be measured to guide further management. Where these are not possible or findings of the assessment are abnormal, delivery is indicated.

Fetal tachycardia

Condition

Fetal tachycardia was defined as heart rate greater than 160 bpm (Figure 2 and Table S3). The condition could be picked up either by intermittent auscultation or continuous electronic fetal monitoring where appropriate.

Assessment and treatment

Initial quick maternal and labour evaluation should gather essential information to facilitate subsequent management. The assessment should begin with the overall analysis of the FHR pattern. Even in the absence of maternal signs of infection, chorioamnionitis should be suspected in cases with persistent or insidious fetal tachycardia, together with late decelerations, meconium liquor, loss of variability or lack of cycling.[50,52] Expedited delivery and cover with antibiotics are needed.

A detailed history taking, physical examination and measurement of vital signs of blood pressure, pulse and temperature would help to differentiate the other causes of fetal tachycardia, which include dehydration, maternal pyrexia or drug-induced. Fluid resuscitation should be started in women with signs of dehydration. If the woman in labour has fever, then antipyretics and physical cooling can bring down the temperature and antibiotics may be considered.

The FHR pattern should be reviewed 30 minutes after conservative management. If FHR pattern/liquor status is suggestive of chorioamnionitis, delivery should be expedited with antibiotic cover. Persistent fetal tachycardia with other non-reassuring or abnormal features requires further evaluation. The non-invasive and easy application of fetal scalp stimulation or acoustic stimulation could be used to assess fetal response. In the context of suspected fetal infection, fetal scalp pH/lactate could be normal and fetal neurological injury could be caused by a non-hypoxic pathway or by lowering the threshold of hypoxia-induced neuronal injury.[50,53] Therefore, clinicians should exercise caution and only select cases with low risk of chorioamnionitis for conservative management.

Discussion

Main findings

We have focused on fetal assessment during labour in low-risk women in a low-resource setting. We have identified the common abnormalities that can be detected clinically using intermittent auscultation and have constructed algorithms to guide management though clinical assessment to identify possible causes, interventions to correct the heart rate abnormalities, reassessment and criteria for operative intervention. Fetal tachycardia and bradycardia or late

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

decelerations are frequently associated with neonatal morbidity and mortality. Prompt and comprehensive evaluation using these clinical algorithms could assist the less experienced birth attendant in a low-resource setting to expedite the delivery of fetuses with a high likelihood of being hypoxic while avoiding unnecessary operative delivery in cases where fetal acidemia/hypoxia is unlikely.

Strengths

The strengths of our paper are that the clinical algorithms are derived from a comprehensive systematic review based on the best available evidence. We used robust, systematic methodology, which was standardised by WHO across this series of algorithms. We have indicated points in our algorithm that link to other relevant algorithms in the series for management of underlying causes of abnormal FHR. We have also highlighted points at which care needs to be escalated for a medical review to manage more complex situations.

Limitations

Limitations include the presence of some inconsistencies among the international guidelines (see Table S1), with no clear evidence to guide assessment of recommendation reliability, as well as lack of evidence for prioritising interventions. Where possible, we based our recommendations on level of evidence, and where evidence was lacking we used the more commonly used recommendations among guidelines or relied on expert consensus of the WHO Intrapartum Care Algorithms Working Group, which may introduce personal bias. For example, the definition of fetal bradycardia was different among various guidelines and we used 100 bpm as the cut-off for our algorithm because this was the most commonly used among the international guidelines.[18–21] Oxygen supplementation was suggested by the WHO Managing complications in pregnancy and childbirth guidance, but its evidence for benefit in the presence of an abnormal FHR pattern was not strong so it was not included in the algorithm.[18]

To make the algorithms reasonably concise for clinical usefulness and practicality we did not include all possible eventualities. The evidence used was geared towards a low-resource hospital setting, and may not be applicable to other clinical settings such as home births. The algorithm is also based on evidence from low-risk pregnancies, and may not be applicable to all high-risk situations.

Interpretation

Current methods to assess fetal wellbeing are inherently inaccurate. They are based on a combination of fetal activity, FHR patterns and fetal responsiveness to stimuli (plus in some settings direct measurement of fetal scalp blood pH or lactate). As with any inaccurate screening or diagnostic test, the possibility exists that inappropriate intervention in false-positive tests will result in more harm from the test than benefit. The ubiquity and increasing popularity of electronic monitoring globally may further exacerbate this phenomenon, in particular in low-resource settings where skilful birth attendants are not available for the correct interpretation of FHR patterns; inappropriate interventions may be based on the fear of fetal hypoxaemia or acidaemia during labour as a major cause of stillbirth and fetal neurological damage. In developing these algorithms, we have attempted to use the best available evidence to strike a balance between detecting most cases of true fetal compromise while avoiding excessive unnecessary intervention.

The only other similar algorithm we identified was based primarily on cardiotocographic findings.[55] The California Maternal Quality Care Collaborative algorithm[54,55] is limited to category II cardiotocograph patterns in labour, and is not included in our algorithm because there is little information on evidence for the guidance. A letter to the editor criticises the algorithm as not being evidence-based, and applicable to the 80% of women who develop this pattern during labour. The FHR tracing and notification guidelines algorithm[56] focuses on the time limit within which the attending doctor or midwife should be informed of the various categories of FHR abnormality. This aspect is not dealt with in our algorithms. The Kaiser Permanente Vallejo Medical Center suggested an algorithm for the management of variant intrapartum FHR tracings (≥32 weeks estimated gestational age);[13] their chart is intended to assist the provider in the management of variant intrapartum FHR tracings. The algorithm has several similarities to our algorithm but is more detailed with respect to cardiotocographic findings, and recommends oxygen therapy, which we do not.

Algorithms by their nature cannot take into account the complexity of clinical conditions. The algorithms may provide general guidance on a logical sequence of decision-making, but in all cases evaluation of the whole clinical setting, including family preferences, should take precedence. The algorithms may also need adaptation according to local resource availability. We have emphasised the lack of robust evidence to support several aspects of the algorithms.

Conclusions

These algorithms may be helpful guides for the process of clinical decision-making in the management of FHR abnormalities during labour, taking into account the caveats mentioned above, and the need to engage in informed, shared, family-centred decision-making. The most important research priority is to seek strategies to assess fetal wellbeing with greater accuracy than is currently possible. This could include research to strengthen the

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

limited evidence on the use of simple clinical fetal arousal testing to augment assessment based on FHR characteristics alone; digital fetal scalp stimulation testing;[57] and confirmation of promising results with the rapid biophysical profile test.[43]

Disclosure of interests

GJH is author of some of the evidence evaluated for inclusion in the algorithms. Evaluation of the evidence was by consensus of the WHO Intrapartum Care Algorithms Working Group. The authors have no other conflicts of interests to declare. Completed disclosure of interests forms are available to view online as supporting information.

Contribution to authorship

OTO and MB conceived the methodology for the development of intrapartum care algorithms for management of labour. OTO, MB and GJH performed the screening of search outputs, identified eligible studies and extracted data. GJH performed the data analysis and developed the algorithms with inputs from KF and the WHO Intrapartum Care Algorithms Working Group. GJH wrote the first draft of the paper. KWC substantially revised the paper. All authors contributed to revising the final version and approved the manuscript for publication.

Details of ethics approval

Ethical approval was not required for this work.

Acknowledgements

We would like to acknowledge the WHO Intrapartum Care Algorithms Working Group for their valuable feedback and contribution to the algorithms

Funding

This work was funded by the Bill & Melinda Gates Foundation (Grant #OPP1084318), The United States Agency for International Development and the UNDP-UNFPA-UNICEF-WHO-World Bank Special Programme of Research, Development and Research Training in Human Reproduction, a cosponsored programme executed by WHO. The funders had no role in design, data collection and analysis, decision to publish or preparation of the manuscript. GJH received salary support from the University of Botswana. KF was self-funded.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Search results flowchart.

Table S1. Summary of evidence table.

Table S2. Annotation table for fetal bradycardia or late decelerations.

Table S3. Annotation table for fetal tachycardia. ■

References

1 Sandall J, Tribe RM, Avery L, Mola G, Visser GH, Homer CS, et al. Short-term and long-term effects of caesarean section on the health of women and children. *Lancet* 2018;392:1349–57.

2 World Health Organization. *WHO Recommendations: intrapartum Care for a Positive Childbirth Experience*. Geneva, Switzerland: World Health Organization; 2018 [https://www.who.int/reproductivehealth/publications/intrapartum-care-guidelines/en/]. 20 March 2020

3 Plotkin M, Kamala B, Ricca J, Fogarty L, Currie S, Kidanto H, et al. Systematic review of Doppler for detecting intrapartum fetal heart abnormalities and measuring perinatal mortality in low- and middle-income countries. *Int J Gynaecol Obstet.* 2020;148(2):145–56.

4 Blix E, Maude R, Hals E, Kisa S, Karlsen E, Nohr EA, et al. Intermittent auscultation fetal monitoring during labour: a systematic scoping review to identify methods, effects, and accuracy. *PLoS One* 2019;14:e0219573.

5 Sholapurkar SL. Critical imperative for the reform of British Interpretation of Fetal Heart Rate Decelerations: analysis of FIGO and NICE guidelines, post-truth foundations, cognitive fallacies, myths and Occam's Razor. *J Clin Med Res* 2017;9:253–65.

6 Alfirevic Z, Devane D, Gyte GM, Cuthbert A. Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. *Cochrane Database Syst Rev* 2017;2:CD006066.

7 Ocak H. A medical decision support system based on support vector machines and the genetic algorithm for the evaluation of fetal well-being. *J Med Syst* 2013;37:9913.

8 Neilson JP. Fetal electrocardiogram (ECG) for fetal monitoring during labour. *Cochrane Database Syst Rev*. 2015;(12):CD000116. https://doi.org/10.1002/14651858.CD000116.pub5

9 Bloom SL, Leveno KJ. Unproven technologies in maternal-fetal medicine and the high cost of US Health Care. *JAMA* 2017;317:1025–6.

10 East CE, Begg L, Colditz PB, Lau R. Fetal pulse oximetry for fetal assessment in labour. *Cochrane Database Syst Rev*. 2014;(10):CD004075. https://doi.org/10.1002/14651858.CD004075.pub4

11 Maiques V, Garcia-Tejedor A, Perales A, Navarro C. Intrapartum fetal invasive procedures and perinatal transmission of HIV. *Eur J Obstet Gynecol Reprod Biol* 1999;87:63–7.

12 Alfirevic Z, Aflaifel N, Weeks A. Oral misoprostol for induction of labour. *Cochrane Database Syst Rev*. 2014(6):CD001338. https://doi.org/10.1002/14651858.CD001338.pub3

13 Mitri F, Hofmeyr GJ, van Gelderen CJ. Meconium during labour–self-medication and other associations. *S Afr Med J* 1987;71:431–3.

14 Mabina MH, Pitsoe SB, Moodley J. The effect of traditional herbal medicines on pregnancy outcome. The King Edward VIII Hospital experience. *S Afr Med J* 1997;87:1008–10.

15 Liabsuetrakul T, Meher S, the WHO Intrapartum Care Algorithms Working Group. Intrapartum care algorithms for liquor abnormalities: oligohydramnios, meconium, blood and purulent discharge. *BJOG*. 2021. https://doi.org/10.1111/1471-0528.16728

16 Souza JP, Oladapo OT, Bohren MA, Mugerwa K, Fawole B, Moscovici L, et al. The development of a Simplified, Effective, Labour Monitoring-to-Action (SELMA) tool for Better Outcomes in Labour Difficulty (BOLD): study protocol. *Reprod Health* 2015;12:49.

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

17 Bonet M, Ciabati L, De Oliveira LL, Souza R, Browne JL, Rijken M, Fawcus S, Hofmeyr GJ, Liabsuetrakul T, Gu€lu€mser C, Blennerhassett A, Lissauer D, Meher S, Althabe F, Oladapo O; WHO Intrapartum Care Algorithms Working Group. Constructing evidence-based clinical intrapartum care algorithms for decision-support tools. *BJOG*. 2021; https://doi.org/10.1111/1471-0528.16958

18 World Health Organization, UNICEF, United Nations Population Fund. *Managing Complications in Pregnancy and Childbirth: A Guide for Midwives and Doctors*, 2nd edn. World Health Organization, UNICEF, United Nations Population Fund; 2017 [https://www.who.int/maternal_child_adolescent/documents/managing-complications-pregnancy-childbirth/en/]. 20 March 2020

19 World Health Organization, United Nations Population Fund, UNICEF. *Pregnancy, Childbirth, Postpartum and Newborn Care. A Guide for Essential Practice*, 3rd edn. World Health Organization, United Nations Population Fund, UNICEF; 2015 [https://www.who.int/maternal_child_adolescent/documents/imca-essential-practice-guide/en/].

20 National Institute for Health and Care Excellence. *Intrapartum Care for Healthy Women and Babies*. London, UK: National Institute for Health and Care Excellence; 2014 [https://www.nice.org.uk/guidance/cg190]. 20 March 2020

21 Creedon D, Atwood L, Bates L, Harper C, Levin A, McCall C, et al. Institute for clinical systems improvement. *Management of Labor*. 2013 [cited 2020 Mar 20]. Available from: http://www.spog.org.pe/web/phocadownloadpap/GUIAMANEJODELPARTO.pdf

22 National Clinical Guideline for Intrapartum Fetal Heart Rate Monitoring Ireland. 2019 [https://rcpi-live-cdn.s3.amazonaws.com/wp-content/uploads/2019/09/National-Clinical-Guideline-for-Intrapartum-Fetal-Monitoring-Guideline.pdf].

23 Martis R, Emilia O, Nurdiati DS, Brown J. Intermittent auscultation (IA) of fetal heart rate in labour for fetal well-being. *Cochrane Database Syst Rev* 2017;2:CD008680.

24 Lutomski JE, Meaney S, Greene RA, Ryan AC, Devane D. Expert systems for fetal assessment in labour. *Cochrane Database Syst Rev*. 2015;(4): CD010708. https://doi.org/10.1002/14651858.CD010708.pub2

25 Khunpradit S, Lumbiganon P, Laopaiboon M. Admission tests other than cardiotocography for fetal assessment during labour. *Cochrane Database Syst Rev*. 2011;(6):CD008410. https://doi.org/10.1002/14651858.CD008410.pub2

26 Devane D, Lalor JG, Daly S, McGuire W, Cuthbert A, Smith V. Cardiotocography versus intermittent auscultation of fetal heart on admission to labour ward for assessment of fetal wellbeing. *Cochrane Database Syst Rev* 2017;1:CD005122.

27 Leathersich SJ, Vogel JP, Tran TS, Hofmeyr GJ. Acute tocolysis for uterine tachysystole or suspected fetal distress. *Cochrane Database Syst Rev* 2018;7:CD009770.

28 East CE, Leader LR, Sheehan P, Henshall NE, Colditz PB, Lau R. Intrapartum fetal scalp lactate sampling for fetal assessment in the presence of a non-reassuring fetal heart rate trace. *Cochrane Database Syst Rev*. 2015;(5):Art. No:CD006174. https://doi.org/10.1002/14651858.CD006174.pub3

29 East CE, Smyth RMD, Leader LR, Henshall NE, Colditz PB, Lau R, Tan KH. Vibroacoustic stimulation for fetal assessment in labour in the presence of a nonreassuring fetal heart rate trace. *Cochrane Database of Systematic Reviews*. 2013;(1):Art. No.: CD004664.

30 Hofmeyr GJ, Lawrie TA. Amnioinfusion for potential or suspected umbilical cord compression in labour. *Cochrane Database Syst Rev* 2012;1:CD000013.

31 Fawole B, Hofmeyr GJ. Maternal oxygen administration for fetal distress. *Cochrane Database Syst Rev* 2012;12:CD000136.

32 Hofmeyr GJ, Kulier R. Operative versus conservative management for 'fetal distress' in labour. *Cochrane Database Syst Rev*. 2012;(6): CD001065. https://doi.org/10.1002/14651858.CD001065.pub2

33 INFANT Collaborative Group. Computerised interpretation of fetal heart rate during labour (INFANT): a randomised controlled trial. *Lancet* 2017;389:1719–29.

34 Raghuraman N, Lopez JD, Macones GA, Tuuli MG, Cahill AG. Does intrapartum maternal oxygen supplementation improve category II fetal heart tracings? *Am J Obstet Gynecol* 2018;218:S184–5. Conference: 38th Annual Meeting of the Society for Maternal-Fetal Medicine: The Pregnancy Meeting. United States.

35 Kamala B. Effectiveness of strap-on Doppler versus intermittent Doppler in abnormal fetal heart rate detection. *Int J Gynecol Obstet* 2018;143:238. Conference: 22nd FIGO World Congress of Gynecology And Obstetrics. Brazil.

36 Mdoe PF, Ersdal HL, Mduma ER, Perlman JM, Moshiro R, Wangwe PT, et al. Intermittent fetal heart rate monitoring using a fetoscope or hand held Doppler in rural Tanzania: a randomized controlled trial. *BMC Pregnancy Childbirth* 2018;18:134.

37 Donnenfeld SR, Knapp J, Esplin I, Snow G, Straubhar A, Heuser C, Holmgren C, Esplin S. Intra and inter observer variance in calculating 30-minute oxygen debt for continuous fetal heart rate monitoring during labor. *Am J Obstet Gynecol* 2018;218:S184. Conference: 38th Annual Meeting of the Society for Maternal-Fetal Medicine: The Pregnancy Meeting. United States.

38 Olofsson P, Noren H, Carlsson A. New FIGO and Swedish intrapartum cardiotocography classification systems incorporated in the fetal ECG ST analysis (STAN) interpretation algorithm: agreements and discrepancies in cardiotocography classification and evaluation of significant ST events. *Acta Obstet Gynecol Scand* 2018;97:219–28.

39 Raghuraman N, Wan L, Temming LA, Woolfolk C, Macones GA, Tuuli MG, et al. Effect of oxygen vs room air on intrauterine fetal resuscitation: a randomized noninferiority clinical trial. *JAMA Pediatr* 2018;172:818–23.

40 Smith V, Begley C, Newell J, Higgins S, Murphy DJ, White MJ, et al. Admission cardiotocography versus intermittent auscultation of the fetal heart in low-risk pregnancy during evaluation for possible labour admission – a multicentre randomised trial: the ADCAR trial. *BJOG* 2019;126:114–21.

41 Mdoe PF, Ersdal HL, Mduma E, Moshiro R, Dalen I, Perlman JM, et al. Randomized controlled trial of continuous Doppler versus intermittent fetoscope fetal heart rate monitoring in a low-resource setting. *Int J Gynaecol Obstet* 2018;143:344–50.

42 Goldenberg RL, McClure EM, Kodkany B, Wembodinga G, Pasha O, Esamai F, et al. A multi-country study of the "intrapartum stillbirth and early neonatal death indicator" in hospitals in low-resource settings. *Int J Gynaecol Obstet* 2013;122:230–3.

43 Housseine N, Punt MC, Browne JL, Meguid T, Klipstein-Grobusch K, Kwast BE, et al. Strategies for intrapartum foetal surveillance in low- and middle-income countries: a systematic review. *PLoS One* 2018;13:e0206295.

44 Langli Ersdal H, Mduma E, Svensen E, Sundby J, Perlman J. Intermittent detection of fetal heart rate abnormalities identify infants at greatest risk for fresh stillbirths, birth asphyxia, neonatal resuscitation, and early neonatal deaths in a limited-resource setting: a prospective descriptive observational study at Haydom Lutheran Hospital. *Neonatology* 2012;102:235–42.

45 Rathore AM, Ramji S, Devi CB, Saini S, Manaktala U, Batra S. Fetal scalp stimulation test: an adjunct to intermittent auscultation in non-reassuring fetal status during labor. *J Obstet Gynaecol Res* 2011;37:819–24.

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

46 Balayla J, Shrem G. Use of artificial intelligence (AI) in the interpretation of intrapartum fetal heart rate (FHR) tracings: a systematic review and meta-analysis. *Arch Gynecol Obstet* 2019;300:7–14.

47 Leung TY, Chung PW, Rogers MS, Sahota DS, Lao TT, Hung Chung TK. Urgent cesarean delivery for fetal bradycardia. *Obstet Gynecol* 2009;114:1023–8.

48 Gull I, Jaffa AJ, Oren M, Grisaru D, Peyser MR, Lessing JB. Acid accumulation during end-stage bradycardia in term fetuses: how long is too long? *Br J Obstet Gynaecol* 1996;103:1096–101.

49 Williams KP, Galerneau F. Intrapartum fetal heart rate patterns in the prediction of neonatal acidemia. *Am J Obstet Gynecol* 2003;188:820–3.

50 Ugwumadu A. Are we (mis)guided by current guidelines on intrapartum fetal heart rate monitoring? Case for a more physiological approach to interpretation. *BJOG* 2014;121:1063–70.

51 Parer JT, King T, Flanders S, Fox M, Kilpatrick SJ. Fetal acidemia and electronic fetal heart rate patterns: is there evidence of an association? *J Matern Fetal Neonatal Med* 2006;19:289–94.

52 Blot P, Milliez J, Breart G, Vige P, Nessmann C, Onufryk JP, et al. Fetal tachycardia and meconium staining: a sign of fetal infection. *Int J Gynaecol Obstet* 1983;21:189–94.

53 Samueloff A, Langer O, Berkus MD, Field NT, Xenakis EM, Piper JM. The effect of clinical chorioamnionitis on cord blood gas at term. *Eur J Obstet Gynecol Reprod Biol* 1994;54:87–91.

54 California Maternal Quality Care Collaborative. *Algorithm for Management of Category II Fetal Heart Rate Tracings*. [https://health.usf.edu/-/media/Files/Public-Health/Chiles-Center/FPQC/FHR-CMQCCAlgorithmsforFHRTracings.ashx?la=en&hash=631A6ABF4D9B909ECB8C899FD09760A7D711AA7B. Assessed on 20 March 2020

55 Clark SL, Nageotte MP, Garite TJ, Freeman RK, Miller DA, Simpson KR, et al. Intrapartum management of category II fetal heart rate tracings: towards standardization of care. *Am J Obstet Gynecol* 2013;209:89–97.

56 Downs T, Zlomke E. Fetal heart rate pattern notification guidelines and suggested management algorithm for intrapartum electronic fetal heart rate monitoring. *Perm J* 2007;11:22–8.

57 Hughes O, Murphy DJ. Comparing second-line tests to assess fetal wellbeing in Labor: a feasibility study and pilot randomized controlled trial. *J Matern Fetal Neonatal Med.* 2020;1–9.

58 Sholapurkar SL. Algorithm for management of category II fetal heart rate tracings: a standardization of right sort? *Am J Obstet Gynecol*. 2014;210(2):175.

Appendix

WHO Intrapartum Care Algorithms Working Group: (in alphabetical order) Livia Ciabati, Lariza Laura De Oliveira (University of São Paulo, Brazil); Dr Renato Souza (University of Campinas, Brazil); Joyce Browne, Marcus Rijken (UMC Utrecht, the Netherlands); Sue Fawcus (University of Cape Town, South Africa); Justus Hofmeyr (Frere Maternity Hospital East London, South Africa); Tippawan Liabsuetrakul (Prince of Songkla University, Thailand); Çağri Gülümser (University of Health Sciences, Turkey); Anna Blennerhassett (University of Birmingham, United Kingdom), David Lissauer (University of Liverpool, United Kingdom), Shireen Meher (Birmingham Women's and Children's NHS Foundation Trust). World Health Organization Secretariat (Switzerland): Fernando Althabe, Mercedes Bonet, A. Metin Gülmezoglu, Olufemi T Oladapo.

Disclaimer. The algorithms are based on best evidence available to date. Responsibility for the interpretation and use of these algorithms lies with the reader. In no event shall the World Health Organization or co-authors be liable for damages arising from its use.

© 2022 John Wiley & Sons Ltd.

14710528, 2024, S2, Downloaded from https://obgyn.onlinelibrary.wiley.com/doi/10.1111/1471-0528.16731 by University Of Witwatersrand, Wiley Online Library on [23/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License