ABSTRACT
Electronic fetal monitoring with special emphasis on cardiotocography (CTG) has become indispensable in the management of pregnancy and labor, especially in the high-risk parturient. While this is an essential part of the practice in high-income countries, many low- and medium-income countries (LMICs) lack the facilities and skill to deploy the technology in their centers. The reasons for this stem from various issues including lack of knowledge on the significance of the tool, lack of training in the acquisition and interpretation of the trace, inordinate fear of the presumed increase in Caesarean section rate, equipment cost and maintenance, among others. In this commentary, the lessons learnt from the 10-year experience of the implementation of CTG monitoring at the Maternal and Fetal Unit of the Department of Obstetrics and Gynecology of the University of Benin Teaching Hospital, Benin City are shared. The basic steps necessary to commence the service are proposed. The issue of training and retraining is emphasized while also highlighting the necessity of preventive maintenance of the equipment. The challenges of the program and limitations of the report are also brought to the fore. Despite these drawbacks, in the spirit of the peer review system for the introduction and sustenance of contemporary medical technology in LMICs, it is believed that sharing these experiences will help build an enduring system capable of improving service delivery and practice in these regions.

Key words: Cardiotocography; electronic fetal monitoring; low- and medium-income countries; University of Benin Teaching Hospital.

Introduction
Electronic fetal monitoring (EFM) involves the use of electronic means to assess fetal heart rate and uterine contractions which could be useful in the management of pregnancy and labor. It consists of the internal monitoring only used in labor as exemplified by the fetal scalp electrodes and intraterine pressure catheters; the external monitoring referred to as cardiotocography (CTG) which can be used both in the antenatal and intrapartum periods. CTG could be defined as the use of a machine—the cardiotocograph—to detect, record, and analyze fetal heart rate changes with time. It also gives a record of the uterine contractions. There is the antenatal and the intrapartum CTG which aims at assessing the fetal health in-utero in order to prevent fetal death from hypoxia. EFM is a standard care in many developed countries. However, this cannot be said in many low- and
medium-income countries (LMICs) because of myriads of reasons as expounded below.

EFM is generally believed to improve fetal outcome. This is despite the lack of concrete scientific evidence to prove this belief. Major scientific research comparing EFM with intermittent auscultation in labor have reported no significant difference in major indices like cerebral palsy and perinatal mortality. Some have reported a slight reduction in the incidence of neonatal seizures. However, there appears to be a near consensus that routine intrapartum CTG increases the incidence of Caesarean section.

The above scientific reports of the drawbacks of EFM have been countered by more recent reviews which have faulted the findings of the studies. Among these is the fact that some of these findings were made many years ago. There have been advancements in the interpretation and use of the CTG technology in more recent years. In addition, certain statistical details have also been faulted based on advancement in knowledge. However, conducting studies in contemporary times to assess the impact of the monitoring techniques has been technically impossible as it could be considered unethical to subject a group of women to no EFM as part of a research when the technology is available. Generally, however, expert opinion favors the selective use of EFM in high-risk pregnancies and labor.

Reasons for the lack of widespread use of EFM in LMICs include cost of the machine and technology, difficulty with machine maintenance, lack of training and expertise on the use of the technology, fear of introduction of a new technology, lack of efficient power supply, among others. The cost of procuring CTG machines may put more strain on a system that is already groaning under the yolk of underfunding. The personnel for, and the cost of maintenance of the machines, is also a potential challenge. There are not many instrument engineers and technicians trained in the maintenance of these advanced technological equipment. Hence, their longevity may be compromised. The cost of the CTG machines and maintenance is juxtaposed against the cost of intermittent auscultation with the traditional Pinard stethoscope that costs the system virtually nothing. Hence, their longevity may be compromised.

Training and expertise on the use of the CTG is a major factor that is considered before its introduction. It is well known that lack of training on the use of new medical technology is one of the major factors that prevent their optimal utilization in LMICs. The CTG is highly user-dependent and some of its drawbacks have been traced to subjectivity of its interpretation. Lack of this training also limits practitioners’ confidence, thereby preventing their acceptance of its use. Many centers may have been unable to overcome the inertia and fear for the introduction of the CTG due to factors related to competence.

Despite the challenges, the CTG is a tool worth introducing in the contemporary antenatal clinic and labor ward. When properly used, it introduces confidence in the management of high-risk pregnancies and acts as an easy to use tool in confirming or refuting suspected challenges in the management of fetal complaints such as reduced fetal movement. In women with previous fetal losses or previous obstetric failures, the CTG evaluation is invaluable in taking objective decision to prolong intrauterine management of the pregnancy to a more favorable gestational age. In women with intrauterine growth restriction, multiple gestation, hypertensive disorders of pregnancy, and other coexisting chronic medical conditions, the CTG is most useful in enhancing decision on time and mode of delivery to optimize fetal survival. In addition, the CTG offers advantages: easy to perform, non-invasive, and has virtually no contraindication.

**Indications for CTG**

**Antenatal**

Routine CTG in pregnancy is believed to increase obstetric interventions without necessarily improving outcome. Based on this, CTG in the antenatal period, where practiced, is reserved for high-risk pregnancies which are indicated by obstetric, medical, and fetal factors. Some of these indications include maternal hypertensive disorders including preeclampsia and eclampsia, diabetes mellitus, antepartum hemorrhage, postterm pregnancy, chronic renal disease, poorly controlled hyperthyroidism, heart disease, hemoglobinopathies, abdominal trauma, and history of previous unexplained perinatal death. Fetal indications include multiple gestation, intrauterine growth restriction, oligohydramnios, polyhydramnios, reduced fetal movement, isoimmunization, and abnormal fetal Doppler velocimetry.

**Intrapartum**

Routine continuous intrapartum CTG is also not recommended neither is routine admission CTG. It is recommended that this investigative modality be reserved for high-risk conditions in labor like induction or augmentation of labor, meconium staining of the liquor, fetal heart rate abnormality noticed on intermittent auscultation, maternal pyrexia, intrapartum hemorrhage, and the use of epidural analgesia. In many of these conditions, intermittent CTG may be...
preferred to continuous CTG with the later reserved for those conditions where the intermittent CTG trace has any suspicious feature.\textsuperscript{[13]}

\textbf{Interpretation of the CTG}

Correct interpretation of the CTG is integral to its usefulness in averting perinatal morbidity and mortality. Subjectivity of CTG interpretation leading to reasonable degree of lack of reliability of the test has been reported.\textsuperscript{[14]} Therefore, it has been advocated that there should be simple universal guidelines for CTG interpretation.\textsuperscript{[15]} Though there have been various classification schemes put forward to classify and interpret the CTG, the International Federation of Gynecology and Obstetrics (FIGO) in 2015 constituted a committee of experts worldwide to help simplify existing criteria. The committee work resulted in the publication of a much-simplified classification of the CTG trace and included recommendations on response to the trace. A sample of this is below [Figure 1].\textsuperscript{[6]}

\textbf{Utility of the CTG}

It is to be understood that the CTG is a screening and not a diagnostic test. It has a high sensitivity (ability to predict a fetus with no features of fetal distress, thereby giving reassurance in a fetus with normal features), but a much lower specificity (the result being abnormal does not necessarily imply that the fetus has hypoxia).\textsuperscript{[13]} Understanding this context will help in reducing the higher intervention rate without a concomitant improvement in perinatal outcome associated with the routine use of the CTG. Training and retraining is of great relevance in achieving this.\textsuperscript{[16]} Pehrson et al.\textsuperscript{[7]} in their systematic review of training in CTG showed improvement in all aspects based on the 4 levels of assessment of training programs proposed by KirkPatrick viz reaction, learning, behavior, and results.\textsuperscript{[17]} Retraining is also an important concept in consolidating learned knowledge and skill.\textsuperscript{[18]} A retraining interval of 6 months has been proposed.\textsuperscript{[19]} Beckley \textit{et al}. also reported the usefulness of repetitive testing of practitioners using the computer-assisted training program in intrapartum fetal monitoring in promoting retention of learned skills like the CTG.\textsuperscript{[20]}

In the interpretation of the CTG, it is important to note certain important factors. In terms of the features of the trace, the more severely abnormal the CTG trace is, the higher the predictive value and the worse the prognosis. The medical condition of the mother and/or the fetus is also a useful consideration. A fetus with features of intrauterine growth restriction that shows abnormal CTG trace is more likely to be truly hypoxic. Certain associated phenomena are also important. Maternal position, febrile illness, fetal anomalies, and drug ingestion are all factors that have been associated with significant CTG changes.

\textbf{Deploying CTG monitoring in LMICs}

Some centers in LMICs have successfully deployed the CTG for antenatal fetal surveillance and in the spirit of the peer review mechanism for improvement of practice in LMICs, some of the experiences are worth sharing. One of the centers that have successfully deployed the CTG is the University of Benin Teaching Hospital in Benin City, Nigeria.

The University of Benin Teaching Hospital has a delivery rate of 3,500 per annum and acts as a tertiary referral center for a population of about 7.5 million. The Department of Obstetrics and Gynecology of the hospital has operated a subspecialty-based unit system since 2001. One of these units is the Maternal-Fetal Medicine unit (MFM). Some of the essential aspects of the departmental functions superintend by the unit include the antenatal clinic, the OBGYN Emergency room, the Prevention of Mother to Child Transmission of HIV center, and the labor ward.

Following years of procrastination, the MFM unit of the department decided to commence the fetal surveillance clinic. One of the major components of this was the CTG room. In order to effectively kick start this monitoring scheme, the unit organized a sensitization and training program. A renowned expert in EFM was available to conduct a workshop on the use of the CTG. This training workshop involved the medical and nursing staff of the department. It included both theoretical and practical sessions. This training formed the base on which the commencement of the service was built. Three new CTG machines were procured for the purpose. Thereafter, an air-conditioned room was secured in the antenatal clinic. The CTG room had a comfortable patient couch, a chair, a voltage stabilizer for electricity, and a UPS system to prevent sudden power shutdown on the CTG machine.
At the onset, the junior resident doctors and house officers were the personnel responsible for conducting the CTG evaluation once this was requested. Once the trace was acquired, it was taken to the senior resident doctors or the consultants for interpretation and necessary action. Over the next few months, it was realized that there were challenges with this system. The rooms were largely unkept, the machines were rarely cleaned, and sometimes they were not shut down after use. There were times when gel smeared probes were left on the floor overnight. It did not take long for the machines to break down. This machine breakdown was presumed to be due to poor maintenance from the users. It is to be noted that once these machines started showing features of malfunction, their lifespan became really shortened even after “successful repair” which most times is unsuccessful. This early machine malfunction led to a major change in the personnel disposition. It was decided that the midwives should be responsible for running the service in the CTG room and acquiring the trace. This was hinged on the fact that they had more control over the cleaning staff of the hospital and they were women; hence, they are presumed to be naturally endowed to care for cleanliness and maintenance. In addition to these, nurses are generally known to be more meticulous on issues of documentation and machine care. They also will be more patient with the operation and gentle handling of the machines and the clients. This was implemented within the first year of the commencement of the service.

Over the next few years, it became obvious that this was the right decision. The rooms were neater, the machines were always put off after use and the probes were well cared for. No wonder the next set of machines lasted over 5 years without need for repair. Whenever a CTG evaluation was requested, this was taken to the midwife who ran the evaluation and took the trace to the requesting team for interpretation and management. The service is presently in its 10th year and many lessons have been learnt which are worth sharing to serve as information to help other centers establish the antenatal CTG service.

Based on our experience, we recommend that every obstetric unit, should have an antenatal EFM service if affordable. Antenatal EFM is necessary in the contemporary management of high-risk pregnancies and confirming the fetal impact of complications occurring in pregnancy. It is also invaluable in the triaging of pregnancies to various levels of care, and in confirmation of some complaints in pregnancy as exemplified by complaint of reduced fetal movement by the parturient. It will be a useful tool in the monitoring of fetuses of mothers with bad obstetric history such as previous intrauterine fetal death, previous stillbirth, and as a useful tool in medical audit.

CTG will assist in early detection of fetal heart rate abnormalities, hence indicating adjustment of care in the clients before irreversible damage occurs. In addition, the recognition of the fact that there is an electronic record of the fetal heart rate will encourage greater attention to the care of the fetus in a parturient in labor. The records from EFM can also act as training and teaching tools, even in cases of fetal demise, to help prevent recurrence. While presently not so common in LMIC, records from EFM can assist in the resolution of medico-legal issues. In areas with severe labor ward staff lack, EFM can come to the rescue, enabling a limited number of midwives monitor fetal health in such staff-constrained labor wards.

The recommendations for setting up and optimizing the antenatal CTG service in LMICs include:

• A practical training workshop/seminar conducted by a professional experienced in the practice of the CTG. This should precede the commencement of the service in the center

• Provision of a dedicated room for the service. The room should be in the antenatal clinic with a comfortable couch and lighting. Having an air conditioner is desirable

• Service should run a minimum of the full routine working hours of the department which is usually between 8.00 am and 4.00 pm on working days in our environment. Operating a 24-h service is ideal

• There should be a dedicated nurse to run the service. She should have at least knowledge of trace acquisition and basic interpretation. Depending on manpower need, the nurse may be a member of the antenatal nursing team who is called upon to carry out the CTG when necessary. However, if the demand for CTG is high and manpower is not a challenge, the nurse can be stationed in the CTG monitoring unit

• At least one CTG machine fit with a power surge protector and a UPS system to maintain power to the device in the event of power loss while the machine is already in use

• Having a computer in place for record purpose is encouraged

• Once a CTG evaluation is needed, the requisite written request is made by the managing team and the test carried out by the nurse. It is recommended that there should be a continuous 20-min trace acquired per client. However, if the demand is high, a normal trace with at least two accelerations acquired in at least 10 min is sufficient. If, however, there is absence of accelerations in 20 min, the
trace could be continued for up to 40 to 50 min during which time, at least two accelerations are expected in a normal healthy fetus. The trace is then sent back to the managing team for interpretation and action. However, if the nurse notices the trace to be pathologic or persistently lacks accelerations, it is advised that she takes direct action to alert the managing team for review and immediate action. The nurse should also be aware of basic maneuvers to undertake in situation when the fetus is not active in a 10-min period such as rocking the uterus, changing maternal position, or giving a cold drink. This is important to avoid raising a false alarm in an innocuous situation.

- The trace should be acquired with the parturient in either the right lateral position or the semi-recumbent position to avoid the supine hypotension syndrome which is associated with lying in the supine position. It is convenient to have an empty bladder. Thereafter, the fetal heart rate is confirmed either with a Pinard stethoscope or a Sonicaid or with the Doppler probe of the CTG machine. A small quantity of coupling agent is applied to the abdominal skin over the region where the fetal heart sound was best heard. The Doppler probe is then applied with the belt maintaining a loose fit. The tocodynamometer is applied close to the fundus of the uterus and also held in place loosely with the elastic belt. The trace is then acquired for the duration as appropriate. CTG machines with multiple Doppler probes can be used to simultaneously acquire traces in twin gestation.

Limitations

While the CTG service at the University of Benin Teaching Hospital has received commendation, there are significant limitations to the reporting of its benefit. One of the major limitations is the lack of adequate records of its service. There was no record system put in place to document procedures done and to track the outcome. This has been seriously hampered by the lack of an electronic storage system in the CTG room. Based on this, quantitative report of use and evaluation done are to be recorded and tracked for eventual outcome. This will obviously add great value to any report of the activities of the center subsequently.

Conclusion

Practice like the establishment of the CTG evaluation unit helps to build the clinical system. Experience gathering also occurs in the process helping to perpetuate the skill. It is expedient that best practices and experience is shared among LMICs, most of which work under similar situations of restricted funding, personnel challenge, and equipment lack. Running services requiring advanced technology as exemplified by the CTG service requires high-level expertise and equipment. This presents a significant challenge and could prevent introduction and utilization in centers in LMICs. However, successful deployment in one of these centers can be a source of impetus for centers in similar circumstances to learn from and do same. There is obviously no need to reinvent the wheel. This is all part of the peer review mechanism aimed at improving service delivery and practice in LMICs.

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Conflicts of interest

There are no conflicts of interest.

References

1. Alfirevic Z, Devane D, Gyte GM. Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. Cochrane Database System Revi 2013;5:CD006066. DOI: 10.1002/14651858.CD006066.pub3.
2. Vintzileos AM, Nochimson DJ, Guzman ER, Knuppel RA, Lake M, Schiffin BS. Intermittent electronic fetal heart rate monitoring versus intermittent auscultation: A meta-analysis. Obstet Gynecol 1995;85:149-55.
3. Devane D, Lalor JG, Daly S, McGuire W, 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. DOI: 10.1002/14651858.CD005122.pub5.
4. Mongelli M, Chung TK, Chang AM. Obstetric intervention and benefit in conditions of very low prevalence. Br J Obstet Gynaecol 1997;104:771-4.
5. Kumar A, Jaju PB. Admission test cardiotocography in labour as a predictor of foetal outcome in high risk pregnancies. Int J Reprod Contracept Obstet Gynecol 2019;8:1331-6.
6. Ayres-de-Campos D, Spong CY, Chandraharaen E, Surbek D, Byaruhanga R, Enabudoso E, et al. FIGO consensus guidelines on intrapartum fetal monitoring: Cardiotocography. IJGO 2015; 131:13-24.
7. Pehrson C, Sorensen J, Amer-Wahlin I. Evaluation and impact of cardiotocography training programmes: A systematic review. BJOG 2011;118:926-35.
8. WHO Reproductive Health Library. WHO recommendation on continuous cardiotocography during labour. The WHO Reproductive Health Library; Geneva: World Health Organization; 2018.
9. Blix E. The admission CTG: Is there any evidence for still using the test? Acta Obstet Gynecol Scand 2013;92:613-9.
10. Impey L, Reynolds M, MacQuillan K, Gates S, Murphy J, Sheil O. Admission cardiotocography: A randomized controlled trial. Lancet 2003;361:465-70.
11. Mitchell K. The effect of the labour electronic fetal monitoring admission test on operative delivery in lowrisk women: A randomised controlled trial. Evid Based Midwifery 2008;6:18-26.
12. Gourounti K, Sandall J. Admission cardiotocography versus intermittent auscultation of fetal heart rate: Effects on neonatal Apgar score, on the rate of caesarean sections and on the rate of instrumental delivery – A systematic review. Int J Nurs Stud 2007;44:1029-35.
13. 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 multicenter randomised trial: The ADCAR trial. BJOG 2019;126:114-21.

14. Santo S, Ayres-De-Campos D. Human factors affecting the interpretation of fetal heart rate tracings: An update. Curr Opin Obstet Gynecol 2012;24:84-8.

15. Sultana J, Chowdhury TA, Begum K, Khan MH. Comparison of normal and abnormal cardiotocography with pregnancy outcomes and early neonatal outcomes. Mymensingh Med J 2009;18(1 Suppl):S103-7.

16. Johnson T. Minimizing risk: Obstetric skills training. J Patient Safety Risk Manage 2003;9:99-102.

17. Kirkpatrick DL. Evaluating Training Programmes: The Four Levels. 2nd ed. San Francisco, CA: Berret-Koehler Publishers; 1998.

18. Larsen DP, Butler AC, Roediger HL III. Test-enhanced learning in medical education. Med Educ 2008;42:959-66.

19. Maternal and Child Health Research Consortium. Confidential Enquiry into Stillbirths and Deaths in Infancy, 4th Annual Report 1997. London: Maternal and Child Health Research Consortium; 1997.

20. Beckley S, Stenhouse E, Greene K. The development and evaluation of a computer-assisted teaching programme for intrapartum fetal monitoring. BJOG 2000;107:1138-44.