Advances in Current Techniques for Monitoring the Progress of Child Delivery

Temitope O. Takpor, Aderemi A. Atayero, *Members, IAENG*

***Abstract*—Monitoring the progress of labour (child delivery) is essential for key clinical decisions to be taken to help manage the wellbeing of both the mother and child during delivery. The key parameters used by doctors and mid-wives to monitor labour progression are cervical dilation, uterine contractions, Fetal Heart Rate (FHR), Fetal Head Station (FHS) and Progression Angle (PA). In this paper, techniques used in monitoring the progress of child delivery are reviewed. In this review, we show how current techniques are used to measure key parameters with more accuracy and less discomfort to the expectant mother as compared to old techniques. Taxonomy of key parameters used for monitoring childbirth progress (cervical dilation and uterine contractions) is provided vis-à-vis old and novel techniques.**

***Index Terms*—Devices, Monitoring, Labour progression, Techniques**

I. Introduction

NEW biomedical devices and techniques for patient monitoring, imaging and diagnosis are important for the advancement of healthcare systems. Perinatal health (maternal and foetal) is a global health concern, and therefore there is a need for frequent and continuous perinatal monitoring particularly during labour progression.

Monitoring labour progression continuously with current or up-coming biomedical devices can help detect maternal labour complications and fetal distresses early enough. Also, advances in techniques and devices can enhance the work of the mid-wives and other labour attendants during child delivery. Real-time monitoring devices and systems that can alert mid-wives on normal and abnormal results will advance labour monitoring. The accuracy of measuring labour progression parameters is very crucial for clinical decisions in determining the option of natural delivery or Caesarean Section (CS) [1]. There have been errors in measuring these parameters through the use of manual methods, and has led to a rise of selective rate of CS. World Health Organization recommends that CS rate should not be above 15% [2]. Recent study shows that highly subjective transvaginal manual examination is unreliable, with errors up to 50% in cervix dilatation and 88% in FHS assessment [2]-[3].

Manuscript received July 27, 2014; revised August 18, 2014.

T.O. Takpor and A.A. Atayero are with Electrical and Information Engineering Department, Covenant University, 112233 Ota, Nigeria (phone:_-+234-816-892-2697;_-email:_-temitope.takpor@covenantuniversity.edu.ng).

There is therefore a need to develop new techniques or improve on existing techniques to accurately monitor labour progression. Improper monitoring before child delivery can have a detrimental effect on perinatal health irrespective of the precautions taken during antenatal period [3]. The key labour progression parameters are cervical dilation, uterine contractions, Fetal Heart Rate (FHR), Fetal Head Station (FHS), Progression Angle (PA). Monitoring of the cervical dilation is the most important way of checking the progress of labour, [4] and cervical dilation values range from 0 cm (no dilation at all) to 10 cm (full dilation) [1-5]. Uterine contraction is also a key parameter used to monitor the progress of child delivery [6].

This paper is organized as follows: In Section II and III, old and novel techniques for monitoring the progress of child delivery are analyzed respectively. Section IV gives a brief taxonomy of old and new techniques adopted for monitoring the progression of child delivery as it relates to two parameters. Finally, conclusions are given in Section V.

II. Old Techniques

Most old techniques are not for continuous monitoring and their accuracies are low. Some of these techniques are discussed below.

A. Digital Technique

It is a highly subjective trans-vaginal manual examination for assessing cervical dilation, which is carried out by a doctor or a midwife inserting his /her fingers through the vaginal opening to detect changes in cervical softening [7]. It is probably the oldest way of carrying out cervical examination. This physical examination method is done routinely and does not guarantee high accuracy since the results vary from one examiner to another. The examiner must be very experienced and highly observant to carry out the cervical examination. This method increases risk of infection to the uterine cavity, which may cause preterm delivery, as well as causing discomfort to the patient [1]. Study shows that in Europe, about 500 000 babies are born prematurely every year [8].

B. Partogram Technique

This technique uses a graph named partograph to outline the progression of cervical dilatation and descent of the FHS as a function of time during labour [5].

C. Electro-mechanical Technique

Electro-mechanical technique uses mechanical calipers or string-type for cervical examination. There are various types of calipers by different people, such as the Friedman

ISBN: 978-988-19253-7-4
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

cervimeter calipers and Siener cervimeter calipers [4]. Calipers normally consist of a centimetre rule at the end, which is used to measure the distance between opposing cervical rims. Some shortcomings of the mechanical cervimeters are discontinuity of readings and lack of recording devices / displays. The cervimeter calipers that have heavy mechanical construction usually interfere with dilation during cervical measurement. The light-weight calipers have cervical clips attached with potentiometers to convert movements of the caliper arms into electrical signals. Fig1. shows the mechanical calipers by Friedman.

The string-type cervimeter is attached to the cervix and it consists of strings. This type of cervimeter monitors cervical dilation through the process of changes in dilatation leading to changes in length of the strings, which are then transmitted to a kymograph mechanically or electrically [4].

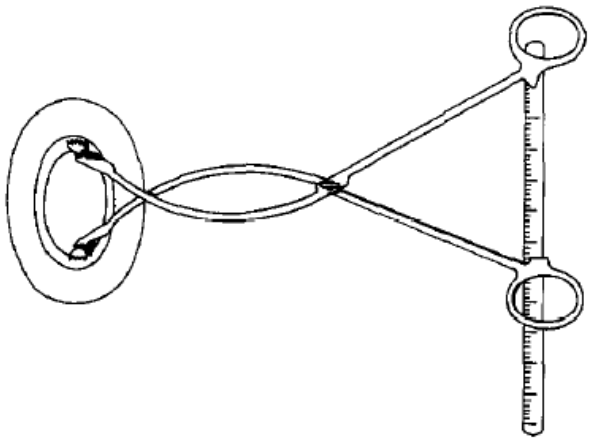

Fig. 1. Friedman's Mechanical Cervimeter [4]

D. Electromagnetic Technique

This technique measures cervical dilatation through the principle of electromagnetic induction. The process involves the use of two small induction coils attached to opposing cervical rims. When one of the coils (coil A) is connected to a signal generator, it sends an electric current hence establishing a magnetic field. The magnetic wave signals generated are then detected by the other coil (coil B) and results are recorded [4]. Both coils actually form a transceiver. Fig. 2 shows the diagram of an electromagnetic cervimeter by Wolf.

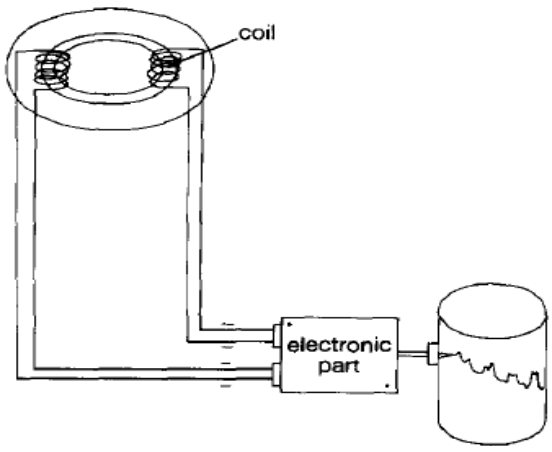

Fig. 2. Wolf's Electromagnetic Cervimeter [4]

E. Ultrasonic Measurement Technique

This technique uses an ultrasonic cervimeter device to measure cervical dilation. The device consists of two ultrasound transducers attached to opposite rims of the cervix. This technique is better than other techniques mentioned above. Though, new and improved real-time monitoring devices are still needed for better accuracy and ease of movement of the mother during labour [1].

F. External Tocography (CTG) and Internal Uterine Pressure (IUP) Techniques

Both techniques use tocodynamometer and IUP Catheter (IUPC) to monitor uterine contractions [9]-[10]. These techniques measure the amplitude, frequency and durations of these uterine contractions. The disadvantages of these techniques are; the CTG technique has low accuracy, while the IUPC is very invasive therefore limited to high-risk deliveries.

III. NOVEL TECHNIQUES

Novel techniques and non-invasive biomedical devices designed for monitoring labour progression are described below.

A. An ultrasound system combined with real-time tracking algorithm and a 2D digital echograph connected to a PC for real-time image processing

This is a noninvasive, quantitative and automatic monitoring system. It is used to measure FHS and PA during labour progression [2]-[3]. A childbirth simulator with an ultrasound probe working conditions was set up. Also, a 2D convex ultrasound transducer was connected to the digital echograph for echographic imaging, signal acquisition, data processing of the birth simulator.

B. Electronic sensor system

This system provides continuous monitoring of cervical dilation. It transmits information wirelessly to a transponder worn like mobile phone or Personal Digital Assistant (PDA). The system is capable of transmitting the progress of dilation wirelessly to a central monitoring agency that can get in touch with the health care personnel [7]. The sensor in the system expands as the cervix dilates, and a dc voltage is produced in proportion to the length between the terminals of the sensor.

C. Uterine electromyography (EMG) Technique

This technique is often called the electrohysterogram (EHG) which is used for measuring uterine contractions and predicting Preterm Labour (PL) [11]. EHG bioelectric signal can be recorded by placing electrodes on the abdominal wall of a pregnant woman [9]-[12]. Various methods are being proposed for EHG modeling and signal analysis. These methods are; pattern recognition methods, filtering methods, Fast Fourier Transform (FFT) methods, and wavelet transform methods [10]. Recently, a new algorithm based on the Teager Energy (TE) operator was proposed as a method for analysing EHG signals for accurate long-term period [10].

ISBN: 978-988-19253-7-4
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

TABLE 1
TAXONOMY OF OLD AND NOVEL TECHNIQUES FOR MONITORING CHILD DELIVERY

Key Parameters	Old Techniques	Novel Techniques
Cervical Dilation	a. Digital Technique (trans-vaginal examination): • Routinely checked • Uncomfortable • Varied results by different examiners • Requires experienced examiners • Increased risk of infection b. Electro-mechanical Technique (mechanical calipers / string-type devices): • Discontinuity of readings • Lack of recording devices • Heavy devices c. Electromagnetic Technique: • Reduced accuracy • Clinical application data are unavailable [4] d. Ultrasonic Measurement Technique: • More accurate than mechanical technique • No discomfort • Expensive ultrasonic terminals • Lack of mobility of the expectant mother	a. Electronic Sensor System: • Non-invasive • Continuous monitoring • Remote monitoring • Ease of movement for the expectant mother • Higher accuracy • Comfortable • Constant readings
Uterine Contractions	a. External Tocography (CTG) Technique: • Low accuracy b. Internal Uterine Pressure Technique: • Highly invasive	a. Electromyography (EMG) Technique: • Non-invasive • Advanced analysis for higher accuracy of results

.

D. Fetal Electrocardiogram (FECG) and Doppler ultrasound devices

These biomedical devices are used to monitor FHR. There are recent techniques in extracting Fetal ECG signals and analysing them through biomedical signal processing to give more accurate results.

IV. TAXONOMICAL OVERVIEW OF OLD AND NOVEL TECHNIQUES

This section highlights taxonomy of old and novel techniques that are used to monitor the progress of child delivery. Table 1 above, shows the taxonomy of old and new techniques that are used to measure two key parameters; cervical dilation and uterine contractions.

V. CONCLUSION

In conclusion, this paper has shown that advances in techniques for monitoring labour progression are necessary because of the ease, comfort and precision these techniques will provide in perinatal healthcare. Perinatal healthcare is very important globally since it deals with the well-being of mother and child. Further work must be carried out to design and develop more devices (such as body sensors), and biomedical signal processes for monitoring labour progression. Advancement in wireless sensor technology should be used to design new biomedical devices. Novel solutions for sensing key parameters for child delivery progression must be considered for enhanced results in perinatal monitoring.

ISBN: 978-988-19253-7-4
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

ACKNOWLEDGMENT

To GOD alone be praised for the wisdom given to write this paper.

REFERENCES

[1] P. Verma, A. Ghosh, R. Huck, S. Cheng, and S. Chen, "Designing a wireless sensor system for continuous monitoring of the cervical dilation of a pregnant woman," *Int. J. Advanced Media and Communication*, vol. 3, 2009, pp. 126-138.

[2] S. Casciaro, F. Conversano, E. Casciaro, G. Soloperto, M. Stark, and A. Perrone, "Quantitative and automatic echographic monitoring of labor progression," presented at the IEEE Int. Ultrasonics Symposium, Dresden, Germany, Oct. 7-10, 2012.

[3] S. Casciaro, F. Conversano, E. Casciaro, G. Soloperto, E. Perrone, G. C. Di Renzo, and A. Perone, "Automatic Evaluation of Progression Angle and Fetal Head Station through Intrapartum Echographic Monitoring," *Computational and Mathematical methods in Medicine J.*, 2013, pp. 1-8.

[4] T. V. Dessel, J.H. Frijns, F.T. Kok, and H.C. Wallenburg, "Assessment of cervical dilatation during labor: a review," *European J. Obstetrics & Gynecology and Reproductice Biology*, Mar. 1991, pp. 165-171.E. H. Miller, "A note on reflector arrays (Periodical style—Accepted for publication)," *Engineering Letters*, to be published.

[5] Y. Sharf, D. Farine, M. Batzalel, Y. Megel, M. Shenhav, A. Jaffa, and O. Barnea, "Continuous monitoring of cervical dilatation and fetal head station during labor," Medical Engineering & Physics J., vol. 29, Jan. 2007, pp. 61-71.

[6] K. Horoba, J. Jezewski, J. Wrobell, S. Graczyk "Algorithm for detection of uterine contractions from electrohysterogram," in *Proc. 23rd Annual IEEE EMBS Int. Conf.*, Istanbul, Turkey, Oct. 25-28, 2001, pp. 2161-2164.

[7] P. Verma, A. K. Ghosh, R. C. Huck, S. Cheng, S. Chen, M. Martens and A. Kaul, "Continuous wireless monitoring of the cervical dilation of a pregnant woman," presented at the 2008 IEEE Int. Workshop on Medical Measurements and Applications, Ottawa, Canada, May 9-10, 2008.

[8] M. Hassan, J. Terrien, C. Muszynski, A. Alexandersson, C. Marque, and B. Karlsson, "Better pegnancy monitoring using nonlinear correlation analysis of external uterine electromyography," IEEE Trans. on Biomedical Engineering, vol. 60, pp. 1160-1166, Apr. 2013.

[9] C. Rabotti, M. Mischi, J. VanLaar, G. Oei and J.Bergmans, "Electrohysterographic analysis of uterine contraction propagation with labor progression: a preliminary study," in Proc. 29th Annual Int. Conf. of IEEE Engineering in Medicine and Biology Society, Lyon, France, Aug. 22-26, 2007, pp. 1-16.

[10] M.J. Rooijakkers, C. Rabotti, S.G. Oei, R.M. Aarts, and M. Mischi, "Low-complexity intrauterine pressure monitoring by teager energy estimation," presented at the 35th IEEE EMBS Annual Int. Conf., Osaka, Japan, July 3-7, 2013.

[11] C. Rabotti, H. Lau, N. Haazen, G. Oei, and M. Mischi, "Ultrasound analysis of the uterine wall movement for improved electrohysterographic measurement and modeling," presented at the 35th IEEE EMBS Annual Int. Conf., Osaka, Japan, July 3-7, 2013.

ISBN: 978-988-19253-7-4
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)