Monitoring of Uterus Electrical Activities using Electromyography in Stage I Induction Labor

Shinta Wurdiana Rhomadona\textsuperscript{1,2}, Melyana Nurul Widyawati\textsuperscript{3}, S Suryono\textsuperscript{4}

\textsuperscript{1}Postgraduate Applied Science Midwifery program Poltekkes Kemenkes Semarang, Indonesia
\textsuperscript{2}Diploma III of Midwifery, Stikes William Booth Surabaya, Indonesia
\textsuperscript{3}Lecturer Postgraduate Applied Science Midwifery program Poltekkes Kemenkes Semarang, Indonesia
\textsuperscript{4}Department of Physics, Faculty of Science and Mathematics, Diponegoro University Semarang, Indonesia

shintawurdian24@gmail.com\textsuperscript{2}, melyana_n@yahoo.com\textsuperscript{2}, suryono@fisika.undip.ac.id\textsuperscript{3}

Abstract. Labor induction is one of the main contributors of serious complication among mothers and babies. Prolonged artificial uterus muscle contraction may result in uterus hyperstimulation. One method of prevention is using the abdomen palpation technique. However, its practice has so far been less effective, less accurate, time consuming, and somehow subjective, as it requires meticulousness of the examiner. The WHO recommends that laboring mothers using induction technique should continuously be monitored. Therefore, there is a need for a much more accurate measure using a monitoring instrument that is capable of recording contraction. The instrument is electromyography. This research analyzed uterus electrical activities in stage I labor induction. The method used was observing 10 respondents undergoing labor induction for their contraction, every 15 minutes for 10 minutes each using electromyography. Monitoring results were then analyzed for frequency, duration, interval, and action potential, and these were presented as a trend. Results show a trend of frequency, duration, interval, and action potential of uterus contraction in stage I labor, with successful induction showing increasing rhythm, while failed induction indicating constant rhythm. Mean frequency, duration, interval, and action potential is 5.30 time/10 minutes, 55.89 seconds, 4.12 minutes, and 1.64V respectively. Meanwhile, the 3 mothers with failed induction have mean frequency of 1.64x/10 minute, mean contraction duration of 21.74 seconds, and mean interval of 7.40 minutes, and mean action potential of 1.18 V.

1. Introduction

Labor induction is usually performed by administering oxytocin or prostaglandin to stimulate uterus contraction prior to normal labor [1, 2], in which the risk of waiting for spontaneous labor is higher compared to the risk of shortening pregnancy duration [3]. Muscle contraction designed to stimulate labor does not always result in per vaginam labor onset [4]. Sometimes it results in failure and hence, dissatisfied mothers and higher risk of operative labor, compared to spontaneous labor [5, 6]. Another possible outcome is myometrium (uterine atony) muscle fatigue, and uterus hyperstimulation [7], umbilical cord prolapse, uterus rupture, placental abruption, hyponatremia, intra uterine infection, postpartum bleeding, mother’s fatigue and emotional crisis [8, 9], as well as fetus emergency with increased risk of NICU (Neonatal Intensive Care Unit) admittance [4].
During the period of intrapartum induction period, monitoring for FHR (Fetal Heart Rate) rhythm and uterus activities is performed strenuously to see possible fetal emergency, uterus hyper stimulation [3]. In order to prevent uterus hyper stimulation, abdomen palpation is performed to evaluate contraction. However, a research suggested that measuring contraction with palpation (fumbling) is less effective and accurate [10]. Abdomen fumbling needs time and sensitivity of the health professional performing it that it is very subjective. Hence, a more accurate method is required [10, 11].

Currently, contraction measurement using fumbling is aimed at knowing the frequency and duration of uterus contraction [11, 12]. The results of which are interpreted into three categories of weak, medium, and strong [12]. Uterus contraction activities and the associated responses determined using palpation lack in accuracy in terms of frequency, duration, and interval [13]. The WHO (World Health Organization) recommends that women receiving oxytocin, misoprostol or prostaglandin need strict monitoring and must not be left unattended [3]. Laboring mothers given induction need more monitoring for contraction, compared to those in normal labor [14, 15]. Therefore, an instrument capable of supporting or monitoring uterus contraction activities whilst providing speedy, accurate, and objective quantities is needed [16].

Available theories suggest that uterus activities during inpartu result from electrical charges stemming from depolarization and repolarization of billions of plain muscle myometrium cells [17-19]. These electrical charges are required to generate adequate contractions to stimulate labor onset [18]. Uterus electrical activities are monitored using EMG (electromyography). EMG comes with an ability of providing speedy, objective, accurate, and clinical information that can be quantitatively measured based on frequency, duration, interval, intensity, contraction tone and electric potential of certain units, that in turn can be used to accurately predict labor [18-20]. Bioelectrical signals from uterus activities are detected by electrodes attached to the abdomen without any need for invasive procedures. These signals are then read by a software that interprets them quantitatively [16, 21, 22]. Therefore, EMG health professionals to make assessment on uterus contraction for laboring mothers using induction. They do so by observing quantities of uterus electrical activities that are interpreted by the software, which indicates frequency, duration, interval, and electric potential [10]. This means that health professionals can then classify contraction more effectively and accurately, compared to using palpation. It is expected that the use of EMG allows speedy and more accurate diagnosis for early detection of possible emergency and success or failure of labor induction, that in turn determines the need for sectio caesaria [6], hence, unnecessary interventions are not performed.

2. Methods
This research employed descriptive and prospective observational design. It was carried out at a hospital in Semarang. The sampling method used was consecutive sampling involving 10 laboring mothers with induction. Data were gathered after respondents agreed to attachment of electrodes on their abdomen. One electrode is attached at the fundus parallel to the umbilicus, and another attached on top of the simpisis parallel to the umbilicus, 2 electrode is attached as ground, each separated 3,5 cm from the umbilicus. Data were taken as respondents started to experience contraction for 10 minutes and they were repeated every 15 minutes, in line with contraction monitoring operational standard for mothers undergoing labor induction. Recording were carried out until opening was deemed complete or until the induction is regarded as failed.

3. Result and Discussion
EMG data of 10 respondents were read and analyzed whilst monitoring the oscilloscope to find out the frequency, duration, interval, and action potential. Results of data analysis are presented in median values and then normalized as to form a trend. The subsequent graph produced then lead to conclusions.

3.1 Analytical Results of Uterus Contraction Electrical Activities in Stage I Labor Induction
Data distribution of uterus activities in stage I labor induction is given in Table 1.
Table 1. Mean Data Distribution of Uterus Electrical Activities in Stage I Induction Labor

| Induction Result | Variable               | Min     | Max     | Mean±SD       |
|------------------|------------------------|---------|---------|---------------|
|                  | Frequency (x/10 minute)| 1.50    | 7.50    | 5.30±1.94     |
| Successful N=7   | Duration (second)      | 38.45   | 88.12   | 55.89±10.04   |
|                  | Interval (minute)      | 3.45    | 5.13    | 4.12±1.50     |
|                  | Action Potential (V)   | 1.05    | 2.04    | 1.64±0.47     |
| Failed N=3       | Frequency (x/10 minute)| 1.4     | 2.4     | 1.32±0.69     |
|                  | Duration (second)      | 20.2    | 22.5    | 21.74±1.59    |
|                  | Interval (minute)      | 7.23    | 7.49    | 7.40±0.14     |
|                  | Action Potential (V)   | 1.04    | 1.58    | 1.18±0.16     |

3.2 Frequency Data Trend of Uterus Contraction Electrical Activities in Stage I Labor Induction

It can be seen in Graph 1 that frequency data trend of uterus contraction among 7 respondents with positive labor induction has a rhythm of higher frequency the closer it is to labor. The maximum mean frequency in successful labor induction is 5.52 times/10 minutes, whereas the minimum is 2.76 times/10 minutes. From measurement 1 to 9, the mean contraction frequency rhythm keeps on increasing, but it lowers on the 10th. Administration of oxytocin drip or misoprostol increases intrauterine tonus that in turn triggers uterus contraction. During stage I labor, oxytocin works in mothers by increasing calcium concentration on the muscles controlling uterus contraction. Increased calcium concentration on the muscles results in increased uterus contraction [23]. Oxytocin works selectively on the plain uterus muscles and causes rhythmic contraction on the uterus, increases contraction frequency, and the tonus of uterus muscles. Repeated and regular administration results in regular contraction.

3.3 Duration Data Trend of Uterus Contraction Electrical Activities in Stage I Labor Induction

It can be seen in Graph 2 that duration data trend of uterus contraction among 7 respondents with positive labor induction has constantly increasing duration with the shortest mean of 55.32 seconds and the longest mean of 82.31 seconds. This is in line with a theory suggesting that the latent phase of uterus contraction lasts from 30 to 45 seconds and is irregular. Meanwhile, for the active phase,
contraction quality is getting adequate with longer duration of 30 - 90 seconds, higher frequency of 2-5 minutes, and stronger intensity, compared to its latent phase counterpart [24, 25]. This both higher frequency and longer duration result in dilation process and quicker hear lowering. Administration of oxytocin and prostaglandin (misoprostol) prolongs uterus contraction that allows adequate mechanism of cervix opening for labor. Oxytocin has proven to stimulate the release of in vitro and in vivo prostaglandin [26], which allow contraction. Cervix ripening to determine the success of labor induction, the number of parity is also an important factor. Women who have given birth before have higher nitride oxide (NO) than those who have not (nullipara). Nitride oxide activates the Matrix Metal Protease (MMP) that in turn affects cervix ripening [26, 27]. NO affects cervix ripening and plays a role in mediating inflammation, regulating MMP - which is responsible for collagen degradation - activity, and induces the production of prostaglandin, by stimulating the activation of oxygenation[28].

3.4 Interval Data of Uterus Contraction Electrical Activities in Stage I Labor Induction

It can be seen in Figure 3 that frequency data trend of uterus contraction among 7 respondents with positive labor induction has a rhythm of lower uterus contraction interval, with the longest mean of 5.35 minutes, and the shortest mean of 2.31 minutes. Contraction interval is part of the depolarization or resting phase in labor. In labor induction, oxytocin increases the work of plain muscles and slows down conduction of electrical activities, that in turn pushes muscle fibers to contract stronger and more often. These pushes are transferred to the cervix and results in cervix extension [8, 21, 29]. The administration of misoprostol per vaginam further helps cervix ripening locally [26].

3.5 Action Potential Data of Uterus Contraction Electrical Activities in Stage I Labor Induction

Action potential data trend of uterus contraction frequency from initial stage I to final stage I induction labor (the moment induction is deemed failed or successful) is shown in Figure 8.

Figure 3. Interval Data Trend of Uterus Contraction in Stage I labor Induction

Figure 4. Action Potential Data Trend of Uterus Contraction in Stage I labor Induction

It can be seen in Figure 4 that action potential of uterus contraction among 7 respondents with positive labor induction has the tendency to rise, whereas the trend is to fluctuate in those with failed labor induction. The maximum mean action potential for successful labor induction is 2.01 V, whereas the minimum mean is 1.07 V. Meanwhile, respondents with failed labor induction has maximum mean action potential of 1.17 V, with a minimum mean of 1.04 V.
Contraction activation in the uterus is the result of electrical activities in the cells of plain muscles. This is indicated by cyclic depolarization and re polarization of plasma membranes, known as action potential. Depolarization is mainly caused by increase in permeability of Ca$^{2+}$ and decrease in permeability of Na$^+$. Oxytocin affects uterus plain muscle contraction via “Ca$^{2+}$ dependent” and “Ca$^{2+}$ independent” mechanism. In the “Ca$^{2+}$ dependent” mechanism, oxytocin receptor in the membranes of plain muscle opens up calcium and sodium ion canals and causes membrane depolarization. Moreover, oxytocin receptors in the membrane that does not open any ion canal can cause internal changes in muscle fabric such as release of calcium ion from intracellular sarcoplasm reticulum, in which the calcium ion later induces contraction. In the “Ca$^{2+}$ independent” mechanism, rho that has bound with phosphate rock activates the myosin of plain muscle via the process of phospholination and it also prevents myosin [21, 30].

4. Conclusion
EMG allows health professionals to monitor stage I labor and predict labor induction more speedily and accurately with reduced unnecessary intervention. Contraction quantity in uterus electrical signal of labor induction has characteristic rhythms.

5. References
[1] D. A. W. Christina A. Penfield, "Labor Induction Techniques: Which Is The Best?", "Obstetrics And Gynecology Clinics Of North America, Vol. Volume 44, 2017, Pp. 567-582, 2017.
[2] World Health Organization, "Recommendations For Augmentation Of Labour: World Health Organization, 2014.
[3] World Health Organization, "Recommendations For Induction Of Labour: Geneva: World Health Organization, 2011.
[4] J. S. Gommers, M. Diederen, C. Wilkinson, D. Turnbull, And B. W. Mol, "Risk Of Maternal, Fetal And Neonatal Complications Associated With The Use Of The Transcervical Balloon Catheter In Induction Of Labour: A Systematic Review," European Journal Of Obstetrics And Gynecology And Reproductive Biology, Vol. 218, Pp. 73-84, 2017.
[5] R. Ryan And F. Mccarthy, "Induction Of Labour," Obstetrics, Gynaecology & Reproductive Medicine, Vol. 26, Pp. 304-310, 2016.
[6] I. Medermott, G. Saade, R. Garfield, And S. Thornton, "Uterine Emg Activity In Women Who Do And Do Not Progress In Labour," American Journal Of Obstetrics And Gynecology, Vol. 193, P. S47, 2005.
[7] J. B. William A. Grobman, Yinglei Lai, Uma M. Reddy, Ronald J. Wapner, Michael W. Varner, John M. Thorp, Kenneth J. Leveno, Steve N. Caritis, Mona Prasad, Alan T.N. Tita, George Saade, Yoram Sorokin, Dwight J. Rouse, Sean C. Blackwell, Jorge E. Tolosa, , "Defining Failed Induction Of Labor, In American Journal Of Obstetrics And Gynecology," American Journal Of Obstetrics And Gynecology 2017.
[8] W. A. Grobman, J. Bailit, Y. Lai, U. M. Reddy, R. J. Wapner, M. W. Varner, Et Al., "Defining Failed Induction Of Labor," American Journal Of Obstetrics And Gynecology, Vol. 218, Pp. 122.E1-122.E8, 2018/01/01/ 2018.
[9] Cunningham, Gant, Leveno, Gilstrap, Hauth, And Wenstrom, Obstetri Williams,Vol 2. Jakarta: Egc, 2001.
[10] P. P. Arrabal And D. A. Nagey, "Is Manual Palpation Of Uterine Contractions Accurate?," American Journal Of Obstetrics And Gynecology, Vol. 174, Pp. 217-219, 1996.
[11] T. A. Santy, Suryono, And M. Nurul, "Aktivitas Kelistrikan Uterus Pada Kontraksi Persalinan Kala 1," Master, Postgraduate Applied Science Program In Midwifery, Semarang Health Polytechnic, Semarang, 2017.
[12] Apn, Asuhan Persalinan Normal Dan Inisiasi Menyusui Dini. Jakarta: Jnpk-Kr, 2011.
[13] E. Hadar, N. Melamed, A. Aviram, O. Raban, L. Saltzer, L. Hiersch, Et Al., "Effect Of An Oxytocin Receptor Antagonist (Atosiban) On Uterine Electrical Activity," American Journal Of Obstetrics And Gynecology, Vol. 209, Pp. 384. E1-384. E7, 2013.
[14] K. R. Simpson And D. C. James, "Effects Of Oxytocin-Induced Uterine Hyperstimulation During Labor On Fetal Oxygen Status And Fetal Heart Rate Patterns," American Journal Of Obstetrics And Gynecology, Vol. 199, Pp. 34. E1-34. E5, 2008.
[15] P. C. Bakker, S. Van Rijswijk, And H. P. Van Geijn, "Uterine Activity Monitoring During Labor," *Journal Of Perinatal Medicine*, Vol. 36, Pp. 184-184, 2008.

[16] G. A. Macones, A. Cahill, D. M. Stamilio, And A. Odibo, "Discussion: 'A New Method For Assessing Uterine Activity'by Haran Et Al," *American Journal Of Obstetrics And Gynecology*, Vol. 206, Pp. E1-E2, 2012.

[17] R. E. Garfield, W. L. Maner, L. B. Mackay, D. Schlembach, And G. R. Saade, "Comparing Uterine Electromyography Activity Of Antepartum Patients Versus Term Labor Patients," *American Journal Of Obstetrics And Gynecology*, Vol. 193, Pp. 23-29, 2005.

[18] M. Lucovnik, W. L. Maner, L. R. Chambliss, R. Blumrick, J. Balducci, Z. Novak-Antolic, *Et Al.*, "Noninvasive Uterine Electromyography For Prediction Of Preterm Delivery," *American Journal Of Obstetrics And Gynecology*, Vol. 204, Pp. 228. E1-228. E10, 2011.

[19] W. L. Maner, R. E. Garfield, H. Maul, G. Olson, And G. Saade, "Predicting Term And Preterm Delivery With Transabdominal Uterine Electromyography," *Obstetrics & Gynecology*, Vol. 101, Pp. 1254-1260, 2003.

[20] B. Vasak, E. M. Graatsma, E. Hekman-Drost, M. J. Eijkemans, J. H. S. Van Leeuwen, G. H. Visser, *Et Al.*, "Uterine Electromyography For Identification Of First-Stage Labor Arrest In Term Nulliparous Women With Spontaneous Onset Of Labor," *American Journal Of Obstetrics And Gynecology*, Vol. 209, Pp. 232. E1-232. E8, 2013.

[21] R. E. Garfield And W. L. Maner, "Physiology And Electrical Activity Of Uterine Contractions," In *Seminars In Cell & Developmental Biology*, 2007, Pp. 289-295.

[22] A. Chkeir, B. Moslem, S. Rihana, G. Germain, And C. Marque, "Mathematical Approach For Modeling The Uterine Electrical Activity," *Physics Procedia*, Vol. 21, Pp. 85-92, 2011.

[23] A. R. Harjanto And M. Muhartonio, "Korelasi Antara Pemakaian Oksitosin Drip Pada Ibu Dengan Angka Kejadian Hiperbilirubinemia Neonatal," *Jurnal Agromedicine*, Vol. 2, Pp. 278-283, 2015.

[24] A. B. Saifuddin, *Buku Acuan Nasional Pelayanan Kesehatan Maternal Dan Neonatal*. Jakarta: Yayasan Bina Pustaka Sarwono Prawirohardjo, 2010.

[25] D. M. Fraser And M. A. Cooper, *Buku Ajar Bidan Myles, Edisi 14*. Jakarta: Egc, 2009.

[26] P. S. Lasmini, I. Yunitra, And H. Bachtiar, "Perbedaan Efek Misoprostol Dan Oksitosin Sebagai Pematangan Serviks," *Andalas Obstetric And Gynecology Journal*, Vol. 2, 2017.

[27] I. P. Dewi And Z. Salmiyati, "Evaluasi Penggunaan Misoprostol Pada Kehamilan Postterm Di Bangsal Kebidanan Rsup Dr. M. Djamil Padang," *Jurnal Ipteks Terapan*, Vol. 10, Pp. 170-175, 2016.

[28] F. Arias, "Pharmacology Of Oxytocin And Prostaglandins," *Clinical Obstetrics And Gynecology*, Vol. 43, Pp. 455-468, 2000.

[29] H. Dania, D. Wahyono, And S. Retnowati, "Perbandingan Efektivitas Misoprostol Dosis 50 µg Dan 100 µg Terhadap Keberhasilan Kelahiran Induksi Di Rsu Pku Muhammadiyah Yogyakarta," *Pharmaciana*, Vol. 4, 2014.

[30] I. L. Buxton, "Regulation Of Uterine Function: A Biochemical Conundrum In The Regulation Of Smooth Muscle Relaxation," *Molecular Pharmacology*, Vol. 65, Pp. 1051-1059, 2004.