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Effectiveness of Continuous Noninvasive Hemoglobin Devices to Monitor the Risk of Postpartum Hemorrhage

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ABSTRACT

Background

The visual estimation method currently used is considered inaccurate, subjective and has not been able to diagnose postpartum hemorrhage correctly. Pulse oximetry is able to measure hemoglobin levels, oxygen saturation and pulse. Pulse oximetry can monitor the risk of postpartum hemorrhage with non-invasive, continuous and real-time.

Objectives

The purpose of this study was to analyze the effectiveness of pulse oximetry in monitoring the risk of postpartum hemorrhage.

Method

This is a quasi-experimental study with a sample size of 30 people. Invasive hemoglobin testing is performed by a hematological analyzer as the gold standard in the intervention and control groups. The examination is carried out twice before delivery (pretest) and 6-24 hours after delivery (posttest). Continued monitoring in the intervention group used pulse oximetry by measuring hemoglobin levels, oxygen saturation and pulse, while the control group used visual estimation and pulse rate manually. The pulse oximetry used in this study is the result of research and development using wavelengths spectrophotometry.

Results

The results showed that the pulse oximetry was able to monitor the risk of postpartum hemorrhage with an effectiveness of 84.6% while the visual estimate was 58.9%. There are differences in the results of measurements of hemoglobin levels using pulse oximetry (noninvasive) and blood sampling (invasive) with an average of 0.288 g / dL.

Conclusion

Pulse oximetry effectively monitors the risk of postpartum hemorrhage continuously and in real time, but blood sampling (invasive) or laboratory analysis is still the gold standard in diagnosing postpartum hemorrhage.

Keywords: Postpartum Hemorrhage, Non-invasive Hemoglobin, Pulse Oximetry, Postpartum Monitoring.

INTRODUCTION

Postpartum hemorrhage is an obstetric emergency. This is the leading cause of maternal death in both developed and developing countries [1]. The mortality rate due to hemorrhage is estimated at 140,000 per year, more than 50% occurring in the first 24 hours after delivery [2]. There are 35% of deliveries postpartum hemorrhage which results in high maternal mortality [3].

In 2015, the Maternal Mortality Rate (MMR) in Indonesia was 305 per 100,000 live births with a percentage of deaths due to hemorrhage which was 30.1% [4]. In Central Java, the maternal mortality rate in 2017 was 88.05 per 100,000 live births and 30.37% is due to hemorrhage [5]. One third of the maternal deaths are due to hemorrhage.

Deaths caused by hemorrhage can be avoided by early diagnosis, proper resources, and proper management [6]. The standard practice for monitoring the risk of postpartum hemorrhage at present is the method of visual estimation of blood loss volume. The visual estimation method is considered inaccurate to determine the amount of blood loss because blood can be mixed with amniotic fluid or urine which can complicate visual estimation by health workers [7]. Whereas the gravimetric method and under-buttock drape are time consuming and difficult to implement in service busy [8]. At present, the method of early detection of postpartum hemorrhage has not been accurate and is not practical for monitoring the risk of postpartum hemorrhage.

The method considered to be accurate is venous blood sampling or laboratory analysis for the determination of hemoglobin (Hb) concentrations [9]. However this method is not real-time requires special equipment and expertise. This method is also not affordable for all health care facilities.

At present, health care facilities require practical, fast, precise and accurate methods to monitor postpartum hemorrhage. Appropriate technology in the health sector is currently being intensively developed. One technology that is considered capable of monitoring the risk of postpartum hemorrhage is the use of oximetry sensors. The basic principle of this sensor is the absorbency of red and infrared light. Oxygen-rich blood and hemoglobin (O2Hb) absorb more infrared light and fewer red lights. While blood with less oxygen and hemoglobin (HHb) absorbs more red light and less infrared [10]. This sensor also uses the principle of blood color. Human blood is bright red when hemoglobin and oxygen levels are high. Meanwhile, when oxygen is released, erythrocytes will turn darker and cause a bluish tint in blood vessels and skin [11]. This principle is the basis of pulse oximetry to measure hemoglobin levels and monitor the risk of postpartum hemorrhage.

Pulse oximetry has been widely used in the medical world as a non-invasive measuring tool. Pulse oximetry can be used as a measurement of hemoglobin levels in the blood [11]. Decreasing hemoglobin levels is a symptom of postpartum hemorrhage [12]. Assessment of hemorrhage by measuring hemoglobin levels is an objective method that is considered the most accurate way to measure blood loss after delivery. This measurement is able to observe biomarkers that can represent the amount of hemorrhage. However, currently measuring hemoglobin levels is done by taking blood (invasive) which is considered ineffective because it must be practiced by experts and requires special equipment. This method is also time-consuming and can cause delay in intervention if the diagnosis relies solely on this method [13]. The use of pulse oximetry as a measurement of hemoglobin levels continuously, real time and non-invasive is needed to monitor the risk of postpartum hemorrhage.

The uniqueness of this study is the analysis of the ability of the pulse oximetry to monitor the risk of postpartum hemorrhage by measuring noninvasive hemoglobin levels, real-time, continuous and lower prices at basic service facilities.

METHOD

This type of research is quantitative research with a quasi-experimental design. In this study, there are two groups that have been given a pretest to determine the initial state and posttest to determine the final state between the experimental group and the control group. Pretest and posttest in both groups were carried out by measuring invasive hemoglobin levels using hematological analysis. Pretest is done before delivery, while posttest is done 6-24 hours after postpartum.

In the intervention group, the pulse oximetry was used to measure noninvasive hemoglobin levels, oxygen saturation and pulse as a risk

monitor for postpartum hemorrhage, whereas in the control group the visual estimation method and manual pulse measurement were used.

The pulse oximetry in this study is the result of the research and development (R&D) of the sensor oximetry from the Nellcor DS-100A DB9 Oximax module brand. Arduino Nano was added as a system controller and data processor. It also added a 3.7-volt battery and step up to increase the power to 5 volts. This tool is also equipped with an LCD, added signal conditioning (LM358), and a wristwatch is formed to facilitate use.



Fig.1 Pulse Oximetry Development



Fig. 2 Pulse oximetry and Hemoglobin strip (Family Dr)

This research was conducted at the Jepara District Health Center from February to March 2020. The population in this study was all mothers who gave birth at the Mlonggo Health Center which were selected by purposive sampling. Sample criteria in this study were vaginal delivery, general conditions within normal limits (pulse, blood pressure, and temperature), and hemoglobin level > 8 g / dl, did not use nail polish, did not smoke and were willing to become research respondents.

The instrument used was a pulse oximetry and hematology analyzer. The development of pulse oximetry has been tested for validation, while the hematology analyzer has been calibrated in February 2020 (before the study). This research was submitted to the bioethics research commission of the Sultan Agung University of Semarang and received an ethical permit on 31 January 2020.

The data in this study are normally distributed and linear so that the linear regression statistical test is performed. Linear regression test is used to determine the strength, direction of the relationship and the effectiveness of the pulse oximetry in predicting the reduction of invasive hemoglobin with a hematological analyzer.

RESULT

Descriptive analysis

Table 1. Distribution of Respondents based on Characteristics

No	Characteristics	Intervention		Control		P
		f	%	f	%	
1	Age					0,417
	a. 16-20 years	2	13,3	4	26,7	
	b. 20-35 years	9	60	8	53,3	
	c. 35-50 years	4	26,7	3	20	
	Total	15	100	15	100	
2.	Number of Children					0,717
	a. Primipara	6	40	7	46,7	
	b. Multipara	9	60	8	53,3	
	Total	15	100	15	100	
3.	Perineal Rupture					1,00
	a. Yes	14	93,3	14	93,3	
	b. No	1	6,7	1	6,7	
	Total	15	100	15	100	
4.	Baby's Weight					0,630
	a. <2500	0	0	0	0	
	b. 2500-3500	12	80	13	86,7	
	c. 3500-5000	3	20	2	13,3	
	Total	15		15	100	
5.	Nutritional Status					1,00
	a. <23,5 (CED)	3	20	3	20	
	b. ≥23,5 (Normal)	12	80	12	80	
	Total	15	100	15	100	
6.	Hemoglobin levels					0,369
	a. 1-8 g/dL	0	0	0	0	
	b. 8-11 g/dL	2	13,3	4	26,7	
	c. 11-17 g/dL	13	86,7	11	73,4	
	Total	15	100	15	100	
7	Postpartum Hemorrhage					0,291
	a. Yes	1	6,7	3	20	
	b. No	14	93,4	12	80	
	Total	15	100	15	100	

**Homogeneous Test*

Based on the table 1, we get data on age, number of children, incidence of perineal rupture, baby's weight, nutritional status, hemoglobin level and postpartum hemorrhage in the treatment and control groups. The data has the same significant p value> 0.05 which means the same or homogeneous.

Table 2. Distribution of measurement results of invasive and non-invasive hemoglobin levels before labor

Hb level	Min	Max	Mean±SD
Invasive	9,6	15,3	12,5±1,50
Non-invasive	10,2	15,7	12,7±1,59

**Descriptive Statistics*

Based on table 2, the average result of hemoglobin measurement with a hematology analyzer (invasive) before delivery is 12.5 g / dL, while the average hemoglobin level with a pulse oximetry (non-invasive) before delivery is 12.7 g / dL.

Table 3. Distribution of measurement results of invasive and non-invasive hemoglobin levels after labor

Hb level	Min	Max	Mean±SD
Invasive	8,4	14,9	11,8±1,65
Non-invasive	9,02	15,24	12,0±1,70

**Descriptive Statistics*

Based on table 3, the average result of hemoglobin measurement with a hematology analyzer (invasive) 6-24 hours after delivery is 11.8 g/dL, while the average hemoglobin level with a pulse oximetry (non-invasive) 6-24 hours after labor is 12.0 g / dL

Inferential analysis

The data in this study are normally distributed and linear, so that a linear regression test can be performed with the following results:

Table 4. Analysis of inferential data

Method	r	R^2	T test	P Value
Visual Estimation	0,768	0,589	4,318	0,001
Pulse Oximetry	0,920	0,846	8,441	0,001

** Linear regression*

The relationship between visual estimation and reduction in invasive hemoglobin levels showed a very strong relationship (r = 0.768). While the relationship of decreased hemoglobin levels using a pulse oximetry and hematology analyzer also showed a very strong relationship (r = 0.920). Both methods are positively patterned. visual estimates and pulse oximetry are higher, the decrease in hemoglobin levels using a hematological analyzer is also higher.

The value of the pulse oximetry determination coefficient is higher than the visual estimation. The pulse oximetry is 0.846 while the visual estimate is 0.589. So it can be interpreted that the pulse oximetry method can predict a decrease in invasive hemoglobin levels with an effectiveness of 84.6%, while visual estimation can predict a decrease in hemoglobin levels with an effectiveness of 58.9%.

Statistical test results on the two methods namely visual estimation and pulse oximetry found a significant relationship with p = 0.001 on visual estimation and p = 0.001 on pulse oximetry. The results of the calculation of the significance test with the t-test obtained t count is 4.318 on visual estimation, while t count on the pulse oximetry is 8.441. Obtained t table for α = 5%, degrees of freedom (df) = 13 and one-tailed test that is 1.771. T value> t table. This shows that there is a real influence between the visual estimation of blood loss volume and pulse oximetry (noninvasive) with a decrease in hemoglobin level with a hematology analyzer (invasive) for 6-24 hours postpartum. The relationship between instruments can be seen in figure 3 and figure 4 as follows:

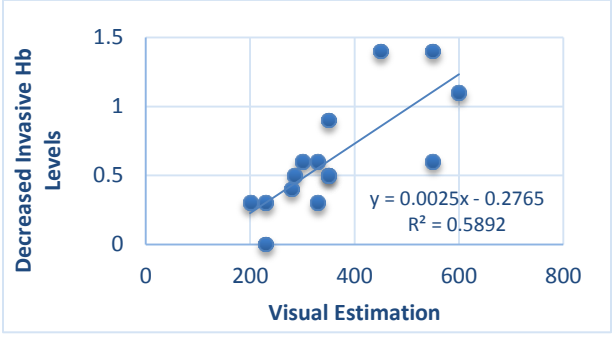


Fig. 3 Visual Estimation Correlation Coefficient Test

There are a number of points outside the regression line. This shows the error of the visual estimation method with r square value of 0.589 or the ability of visual estimation in predicting the decrease in hemoglobin levels in respondents by 58.9%.

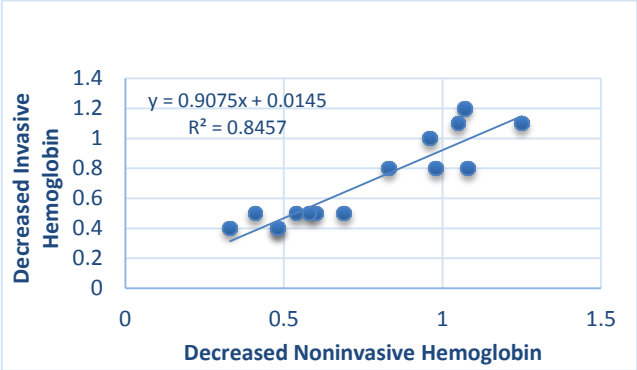


Fig. 4 Pulse Oximetry Correlation Coefficient Test

There are several points outside the regression line. This shows the error of the pulse oximetry method with r square value of 0.8457 or the ability of the pulse oximetry to predict a decrease in hemoglobin levels in respondents by 84.6%.

DISCUSSION

Based on the results of this study, it was found that visual estimation had an effectiveness of 58.9% while the development of pulse oximetry had an effectiveness of 84.6% in predicting a decrease in invasive haemoglobin levels. Some researchers have claimed that the visual estimation method is inaccurate and estimates lower blood loss than it should have [9, 14-16]. Research shows that the sensitivity of visual estimation measurements is 40% for vaginal delivery [17]. the risk of postpartum hemorrhage with a visual estimation method is subjective, inaccurate and can skip several cases of postpartum haemorrhage.

The development of pulse oximetry is a new innovation in monitoring and improving patient care. The advantage of developing pulse oximetry is that it monitors haemoglobin levels continuously [18]. In this study, the effectiveness of pulse oximetry is higher than visual estimation. Pulse oximetry is able to monitor the risk of postpartum hemorrhage with an accuracy rate of 84.6% while the visual estimate is 58.9%.

The design of heart rate measuring devices, oxygen saturation and haemoglobin levels using a pulse oximetry (MAX30100) was carried out. The measurement results of this tool has an error rate of 3.8% and an accuracy rate of 96.2% for measuring haemoglobin, an error of 3.1% and an accuracy rate of 96.9% for measuring hearth rate, 1% error and an accuracy rate of 99% for measuring saturation oxygen [19].

In this study, there were different haemoglobin levels using "venous blood sampling" (invasive) and haemoglobin levels using pulse oximetry (non-invasive). The average difference in decreasing haemoglobin levels using venous blood and pulse oximetry withdrawals was 0.288 g / dL. This shows that the results of examination of haemoglobin levels using pulse oximetry (non-invasive) and blood sampling (invasive) are not the same as the average difference in the results of the examination which is 0.288.

The average pulse oximetry error that was found berkow [20] was 0.33 g / dL for all data. Macknet et al found an error of 0.15 g / dL and a precision of 0.92 g / Dl [21]. Frasca et al found an error of 0.0 g / dL and a precision of 1.0 g / dL [22].But there are other studies that are not in accordance with this study. Although SpHb often correlates well, Miller concluded that there was a difference of 1.5 g / dL in 39% of his observations [23].Gayat et al showed greater error and precision (1.8 and 2.6 g / dL) [24]. This might be possible because there are different methodologies and ways of collecting data from gayat research and this research. Gayat uses the pulse oximetry as a "Spot Check" not for continuous monitoring. Gayat's research also does not pay attention to signal quality indicators. In this study the comparison of manual pulses and red pulses on the pulse oximetry are used as an indicator of signal quality.

All devices have built-in errors; devices that analyze blood have a greater error rate. Sampling techniques, handling and technical factors of using the device are one of the main causes [25]. In the use of this pulse oximetry, there are several factors that can affect the inaccuracy of the examination results, namely compression on the finger or the installation of the probe is too tight or the size of the finger is too large, the movement respondents, the use of nail polish, room light, physical conditions such as patients (vasoconstriction and hypothermia at the fingertips).

At the time of using the pulse oximetry, there were 2 respondents who dropped out. This is because the respondent used black nail polish and there was 1 respondent who had long nails. this interferes with the absorption of red and infrared light on the pulse oximetry. this also makes it difficult to install the pulse oximetry sensor. Respondents who had black nail polish revealed a higher hemoglobin level of 15.6 g / dL, while the results of laboratory tests were 12.3 g / dL. Whereas in patients who have long nails, finger placement is not right on the sensor. So the results obtained are lower than the results of hemoglobin laboratory tests.

Measuring with a pulse oximetry is not a substitute for laboratory tests for hemoglobin, but it is realtime and continuously able to detect early decreases in hemoglobin levels in the blood and monitor the risk of postpartum hemorrhage. Pulse oximetry is able to provide data continuously, non-invasive and in real time. SpHb (Saturation of Peripheral Hemoglobin) monitoring offers a new paradigm and opens new possibilities for improving patient care [18]. The use of this monitor as part of routine patient care can enable health workers to focus on other aspects of management [26].

CONCLUSIONS

Pulse oximetry is able to monitor the risk of postpartum hemorrhage with an effectiveness of 84.6% while the visual estimate is 58.9%. There are differences in the results of haemoglobin levels using pulse oximetry (non-invasive) and venous blood sampling (invasive) with an average value of 0.288 g / dL.

REFERENCES

[1]. M. Belfort, “Overview of postpartum hemorrhage”, 2018.
[2]. WHO, “Maternal, newborn, child and adolescent health Adolescent development,” WHO Press, 2015, 1-2.
[3]. World Health Organization, “Countdown to 2015 decade report with country profiles: taking stock of maternal, newborn and child survival.” Matern. Newborn Child Surviv. Countdown to 2015, 53.
[4]. Badan Pusat Statistik, Badan Koordinasi Keluarga Berencanan Nasional, Departemen Kesehatan, dan Macro International, “Survei Demografi dan Kesehatan Indonesia, 16, 2013.
[5]. Dinas Kesehatan Jawa Tengah, “Profil Kesehatan Provinsi Jawa Tengah,” Dinkes Jateng, 3511351, 24, 2017, 1–62.
[6]. Varney, “Varney. Buku Ajar Asuhan Kebidanan. Jakarta : EGC ”, Jakarta EGC, 2010.
[7]. V. Diaz, E. Abalos, dan G. Carroli, “Methods for blood loss estimation after vaginal birth”, Cochrane Database of Systematic Reviews, 9, 2018.
[8]. H. M. F. Al Kadri, B. K. Al Anazi, dan H. M. Tamim, “Visual estimation versus gravimetric measurement of postpartum blood loss: A prospective cohort study,” Arch. Gynecol. Obstet., 283(6), 2011, 1207–1213.
[9]. M. N. Schorn, “Measurement of Blood Loss: Review of the Literature,” J. Midwifery Women’s Heal, 55(1), 2010, 20–27.
[10]. E. D. Chan, M. M. Chan, dan M. M. Chan, “Pulse oximetry: Understanding its basic principles facilitates appreciation of its limitations,” Respiratory Medicine, 107(6), 2013, 789–799.
[11]. Pricilia, “Rancang bangun alat ukur kadar hemoglobin dan oksogen dalam darah dengan sensor oximater secara non-invasive,” J. Tek. Pomits, 3(2), 2014, 1–2.
[12]. L. De Lloyd., Standard haemostatic tests following major obstetric haemorrhage, Int. J. Obstet. Anesth., 20(2), 2011, 135–141.
[13]. K. T. Gabel dan T. A. Weeber, Measuring and Communicating Blood Loss During Obstetric

Hemorrhage, JOGNN - J. Obstet. Gynecol. Neonatal Nurs., vol. 41(4), 2012, 551–558.
[14]. T. Lertbunnaphong, N. Lapthanapat, J. Leetheeragul, P. Hakularb, dan A. Ownon, Postpartum blood loss: Visual estimation versus objective quantification with a novel birthing drape, *Singapore Med. J.*, vol. 57, no. 6, hal. 325–328, 2016.
[15]. H. Tixier, C. Boucard, C. Ferdynus, S. Douvier, dan P. Sagot, "Interest of using an underbuttocks drape with collection pouch for early diagnosis of postpartum hemorrhage," Arch. Gynecol. Obstet., 283(1), 2011, 25–29.
[16]. K. Dunlop, R. Eckler, A. Rosen, A. Komorowski, K. Murphy, dan R. D'Souza, "Reliability of Visual Estimation of Intrapartum Blood Loss [10Q]," Obstet. Gynecol., 129, 2017, 175S-176S.
[17]. S. J. Barker, A. Shander, dan M. A. Ramsay, "Continuous Noninvasive Hemoglobin Monitoring," Anesth. Analg, 122(2), 2016, 565–572.
[18]. D. A. Prasetyo, "Rancang Bangun Alat Ukur Denyut Jantung, Saturasi Oksigen dalam Darah dan Hemoglobin dengan Metode Noninvasive," Universitas Muhammadiyah Purwokerto, 2019.
[19]. L. Berkow, S. Rotolo, dan E. Mirski, "Continuous noninvasive hemoglobin monitoring during complex spine surgery," Anesth. Analg, 113(6), 2011, 1396–1402.
[20]. M. R. MacKnet, M. Allard, R. L. Applegate, dan J. Rook, "The accuracy of noninvasive and continuous total hemoglobin measurement by pulse CO-oximetry in human subjects undergoing hemodilution," Anesth. Analg, 111(6), 2010, 1424–1426.
[21]. D. Frasca, "Accuracy of a continuous non-invasive hemoglobin monitor in the ICU," Crit. Care, 15(1), 2011, 429.
[22]. R. D. Miller, T. A. Ward, S. C. Shiboski, dan N. H. Cohen, "A comparison of three methods of
[23]. hemoglobin monitoring in patients undergoing spine surgery," Anesth. Analg, 2011.
[24]. E. Gayat, "Performance evaluation of a noninvasive hemoglobin monitoring device," Ann. Emerg. Med., 2011.
[25]. B. Altman, "Statistical methods for assessing agreement between," lancet, 62(7), 1986, 307–310, 2018.
[26]. J. B. F. Filho, G. U. Eckert, M. B. Tartarella, dan R. S. Procianoy, "Prevention of retinopathy of prematurity", Arquivos Brasileiros de Oftalmologia, 74(3), 2011, 217–221.

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