MODERN TECHNOLOGY TO DIAGNOSE
EARLY POSTPARTUM HEMORRHAGE IN ISLAND AREAS
: *A SYSTEMATIC REVIEW*

by
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Article Info	ABSTRACT
	Mortality and morbidity due to bleeding occur due to delayed care. On the island, more advanced technology models based on the 4.0 digital development facilities and infrastructures are important to improve the health service quality. This literature review identifies modern technology-based bleeding detection as an effort to detect and diagnose early postpartum hemorrhage on the island. This systematic review study selected the data with the PRISMA protocol method. The researchers took 12 journal article outlets with years of publications from 2011 until 2020. The researchers found 587 articles. However, the most relevant articles with the applied keywords were 12 articles. Various modern technology-based detections for bleeding applied pantograph, gravimetric, bag collector, under-buttock, SAPHE mat, and scoring measurement to efficiently promote early bleeding. These investigated models were more effective than visual estimation with effectiveness percentages of 25-89%. Technology-based detections could early detect and facilitate postpartum hemorrhage and provide immediate care. High technological advancement in the health field facilitates the patients' care, especially in islands that need immediate action. The results of this research are useful to promote further research about modern-technology-based models to detect and diagnose postpartum hemorrhage in islands. *This is an open access article under the license.*

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1. INTRODUCTION

The mortality rates of mothers indicate the health levels of women in a country. World Health Organization (WHO) considers the mortality rate of mothers an important issue [1]. Based on WHO data in 2017, every day, 810 women passed away due to complications during the periods of pregnancy and childbirth. From 2000 until 2017, the mortality rate of mothers was 100.000 life birth decreased by about a percentage of 38% in the world. The mortality rate of mothers in the world is 94%, observable in low and moderate-income countries [2]. The mortality rate of mothers in Indonesia is considered high, 305 per 100.000 life birth. The causes of this mortality rate include hypertension (33.07%), non-obstetric complications (15.27%), other obstetric complications (12.04%), pregnancy infection (6.06%), and other cases (4.81%). In this case, the cause due to postpartum hemorrhage is 27.03%. Thus, postpartum hemorrhage becomes the second factor in the mother mortality rate [3].

The postpartum hemorrhage causes hypovolemic shock and leads to increased SHEEHAN syndrome risks. SHEEHAN syndrome is a predictor of atrophy and necrosis cases of *master of the gland,* and pituitary gland with various severities so that the secretion of the tropic hormone is interrupted. The syndrome can also lead to mortality. In island areas, the immediate postpartum hemorrhage cares encounter many challenges because the cases cannot be detected earlier. Thus, innovative detecting and diagnosing services are important. Many promoted efforts to decrease the mortality rates of mothers due to postpartum hemorrhage include medical workers' skills, infrastructure

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improvements, referral systems, and supportive facility and infrastructure provisions [1]. The implementations of advanced technology models and 4.0 digital-based technologies in health facilities and infrastructures improve the health service. Thus, innovation to measure postpartum hemorrhage is important. The detection of postpartum hemorrhage belongs to the early detection effort to manage the postpartum hemorrhage immediately. Currently, the efforts to early detect postpartum hemorrhage apply visual and subjective methods by health workers due to infrastructure limitations and inadequate laboratory facilities [4]. Many advanced countries can predict the bleeding occurrences during the delivery because of the implementation of early detection technology development for postpartum hemorrhage cases. Technology-based detections could early detect, diagnose, and provide immediate care for postpartum hemorrhage [5].

High health field technology advancement facilitates the patients' care, health care service cost reduction, and health care worker scale improvement to help many people. Technology for health fields creates excellent communication among health workers and the patients. The implementation of modern instruments for health care service can cover wider areas of community, health facilities, and technology facilities in islands for better accessibility.   The implementation of modern technology is important to improve detection, diagnosis, and therapy qualities to medicate the patients. These technology implementations can support the full recovery medication for the patients [5]. Information technology allows many things to do. In the health field, information technology provides many advantages, such as space efficiency, immediate care service, accessibility, controllability, data processing facility, and less paper use. Information technology also saves time and effort to process data [6].

2.   RESEARCH METHOD

Research Design and Searching Process

This systematic review study selected the data with the PRISMA protocol method. The researchers searched the articles from January 15, 2020, until February 12, 2020. Then, the researchers obtained 12 articles to review. They were from Science Direct (5 articles), PubMed (2 articles), and Google Scholar (5 articles). The applied keywords to search the articles were 'postpartum hemorrhage,' 'measurement of blood loss,' and 'postpartum hemorrhage detection.'

The Inclusive Criteria

The applied criteria to select the articles were English written text articles, full-text availability, and publication from 2011 until 2020. In this case, the researchers did not limit the research designs. The researchers excluded the documents if they were a final project of a bachelor's degree, thesis, manual or guideline, duplicated article, and article with irrelevant keywords.

Data Collection Techniques

The applied standard protocol to select the article was PRISMA, *Preferred Reporting Items for Systematic Reviews, and Meta-Analyses.* The researchers identified 587 articles and screened the articles based on the titles and relevant abstracts. Then, the researchers determined the articles' relevances based on the full-text availability. In this process, the researchers obtained 14 included articles for the skimming process. After checking the duplicated articles, the researchers found only 12 articles that met the inclusion criteria for further review.

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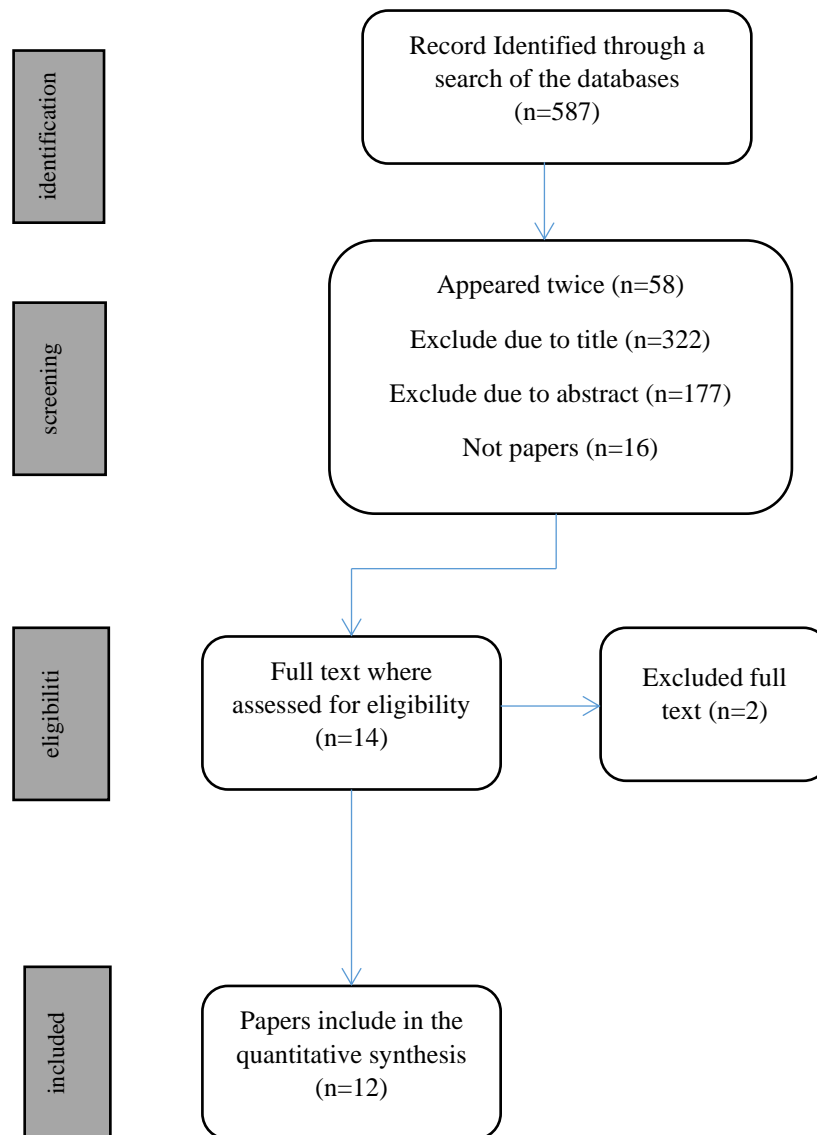
Data Extraction

Figure 1. Data Extraction with PRISMA Protocol

3.   RESULTS AND ANALYSIS

The reviewed articles, 12 articles, consisted of 8 articles discussing hemorrhage detecting methods and measuring blood loss, one article discussing the early identification potential of postpartum hemorrhage, and 3 articles focusing on modern technology-based hemorrhage diagnostic methods and effective management to prevent postpartum hemorrhage.

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3.1. Detecting the Hemorrhage and Measuring the Blood Loss with Modern Technology
Table 1. Detecting the Hemorrhage and Measuring the Blood Loss with Modern Technology

No.	Titles	Method	Sample	Intervention	Results
1.	Digital Scales of Web-Based Partograph in Detecting the Early Postpartum hemorrhage

Sry Wahyuni, Mardiana Ahmad, Syafruddin Syarif, Nasrudin A. Mappaware, Prihantono, Burhanuddin Bahar,2019 | Quasi-Experimental | The researchers took 30 labor and delivery mothers with a purposive sampling technique. | The research used web-based digital partograph measurement and conventional partograph measurement to detect the hemorrhage estimation for the III and IV periods. | The web-based digital partograph measurement could quickly estimate the postpartum hemorrhage for the third and fourth periods more than the conventional partograph measurement. The evidence is the result of the Mann-Whitney statistic test with a p-value > 0.05, indicating the differences in the processing speed. However, the accuracy of both measurements was not significantly different for both the third and fourth periods, as proven by the p-value score, higher than 0.05. |
| 2. | Measurement of blood loss during postpartum hemorrhage

G. Lilley, D. Burkett-st-Laurent, E. Precious, D. Bruynseels, A. Kaye,
J. Sanders, R. Alikhan, P.W. Collins, J.E. Hall, R.E. Collis, 2015 | Prospective Cohort | The researchers applied the research to 356 patients out of 6187 patients with postpartum hemorrhage in South East Wales for 52 weeks. | The geometrical measurement is compared to the visual estimation made by the health workers. | The results clinically showed the correlation of gravimetric measurement of blood loss with hemoglobin decrease during postpartum hemorrhage for more than 1500 mL.
The applied method was easy to apply. The method only needed basic assessment and many labor care service providers could learn the method to manage postpartum hemorrhage. The correlation coefficient between the measured blood loss and the improved hemoglobin decrease for all patients was 0.77 for postpartum hemorrhage of more than 1500 mL. |
| 3. | The Effectiveness of a Collector Bag for Measurement of Postpartum Hemorrhage

Zahra Abbaspoor, and Leila Vaziri, 2017 | Analytic-diagnostic research involved 100 women treated in the hall of Shohada Hospital, Orumeyeh, Iran. | | The researchers assessed the sensitivity, specification, positive predictive value (PPV), negative predictive value (NPV), bag collector, and the correlation with the variances of hemoglobin (Hb) and hematocrit (Ht). | The research showed that the bag collector put on the waists of patients was the most immediate and accurate procedure to estimate the blood loss visually, quantitatively, and objectively. The bag collector was simple to diagnose postpartum hemorrhage. The sensitivity score of this procedure was 80%. |
| 4. | Visual estimation versus objective quantification with a novel birthing drape
Tripop Lertbunnaphong, Numporn Lapthanapat, Jarunee Leetheeragul, Pussara Hakular, Amporn Ownon, 2016 | Study prospective (cohort) | The researchers researched 286 pregnant women in Thailand aged older than 18 years old and treated during the initial labor phase. | The objective measurement applied sterilized under-buttock drapes to determine the blood loss volumes during postpartum hemorrhage. | The results showed the significant differences in postpartum hemorrhage blood loss between visual estimation and objective measurement with under-buttock drapes $(178,6 \pm 133,1$ mL vs $259,0 \pm 174,9$ mL with p <0,0001).
The researchers found inaccurate estimation for the separated category of postpartum hemorrhage blood loss within 100 mL. The estimation was low with lower correspondence, 27.6% (Kappa Cohen coefficient, 0.07; p < 0.05), than the objective measurement with an under-buttock drape. |
| 5. | Diagnosing Postpartum | Quasi-experiment | The researchers involved 36 | The researchers calculated the | The estimated results of visual blood loss were stated in 100 mL. |

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	Hemorrhage: A New Way to Assess Blood Loss in a Low-Resource Setting *Lorine Wilcox, Chethan Ramprasad, Amanda Gutierrez, Maria Oden, Rebecca Richards-Kortum, Haleh Sangi-Haghpeykar, Manisha Gandhi,* 2016		vaginal delivery patients with SAPHE Mat.	estimated blood loss with SAPHE Mat by multiplying the numbers of saturated blood contact with partial blood contact, 50 mL. The researchers compared the visual EBL with the actual blood loss calculated based on the difference between pre-used and post-used mats. This calculation determined the volume of the blood loss.	The blood loss volume was 69% based on the period and 200mL at 97% based on the period. The difference between EBL visual and blood loss values (the Mat weight differences) was 80.91 mL. The Pearson correlation coefficient for EBL visual and positive blood loss volume was 0.96, ($p < 0.001$).
6.	Predicting Postpartum Hemorrhage (PPH) during Cesarean Delivery Using the Leicester PPH Predict Tool: A Retrospective Cohort Study *Suzanna E. Dunkerton, Yadava B. Jeve, Neil Walkinshaw, Eamonn Breslin, Tanu Singhal,* 2018	A retrospective cohort study	The researchers involved 24.230 women that received a cesarean surgery.	The applied instrument to predict postpartum hemorrhage was Leicester Predict.	The results showed the applied instrument, Leicester Predict. could predict the significant risk of PPH after receiving cesarean surgery with pra-major cesarean surgical characteristics. The instrument to assess the risk showed excellent reliability results during the internal validation test. The implementation of this instrument was clinically practical to prevent and promote strategies for minimizing blood loss in high-risk patients. The researchers used the predicted PPH score with the Leicester test. Then they randomly selected the data. The remaining data percentage was 25% (n ¼ 6095) of the total data for the internal validity test. The reliability test showed a correlation of 0.98. This result indicated an average error of 239.8 mL from the actual results.
7.	Risk Scoring System for the Prediction of Postpartum Blood Loss over 300 mL at Chiang Rai Regional Hospital *Natakorn I-Tuporn, M.N.S., Amornrat Ratanasiri, Ph.D., Thitima Nutravong, Ph.D., Kultalee Boonprasert, M.D., Tasanee Na Pikul, M.N.S.,* 2019	A retrospective case control study case	504 cases, 72 cases: 4320 control, of pregnant women with gestational age older than 28 weeks and vaginal delivery.	The form has eight predictors: • Age of the mother • Gestational age • Multipara incidents • Curettage history • Gestational hypertension • Anemia • Fundal Height > 38 cm • The patients received pethidine to	The form could predict the postpartum hemorrhage blood loss for more than 300 mL after vaginal delivery with 80.7% sensitivity, 60.8% specification, and 0.71 ROC curve result with optimal cut-off scores for more than four points. The form could predict the postpartum hemorrhage blood loss for more than 500 mL after vaginal delivery with 88.1% sensitivity, 54.6% specification, and 0.71 ROC curve result with optimal cut-off scores for more than three points.

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No.	Titles	Method	Sample	Intervention	Results
					lose the pain during the first day of work.
8.	Postpartum Blood Loss Measurement Using Digital Image Processing *Siska Febrina Fauziah, Suryono, Melyana Nurul Widyawati*, 2018	The researchers applied measurement for postpartum hemorrhage blood loss.	The characteristics of the absorbed blood on the underpad were observable on 30 blood figures from 10 different sample variances.	The researchers validated the digital imagery process to measure blood loss during the delivery. The researchers promoted a catheterization procedure to determine the blood absorbency on the digital figure and the blood volume on the underpad.	The results showed the areas and the volumes of the absorbed blood on the underpad had a significant and linear correlation, R = 0.9734. The digital imagery process was useful to determine the postpartum hemorrhage blood loss accurately, 83.7%. Therefore, the implementation of this method could be an accurate and objective alternative to other available methods. On the other hand, the implementation of this new method should obey the standard operational procedure of labor care to provide maximum service.

3.2. Identifying the Early Potency of Postpartum Hemorrhage with Modern Technology
Table 2. Identifying the Early Potency of Postpartum Hemorrhage

No.	Titles	Method	Sample	Intervention	Results
1.	Early potential metabolic biomarkers of primary postpartum hemorrhage based on serum metabolomics *Tingting Chen, Ruoxi Zhang, Yidong Zhang, Wenjun Yuan,* 2019	Quasi Experimental	Thirty healthy pregnant women and 30 women with postpartum hemorrhage cases	The Liquid Chromatography-quadruple-time-of flight mass spectrometry, LC-OTOFMS, and the identified biomarker could detect the metabolic serum of all pregnant women.	The researchers found 34 significant occurrences, $p < 0005$, that could change the metabolic serum. This finding was observable in the pre-postpartum hemorrhage group, especially those with fatty acid and glycerophospholipid metabolisms. LysoPCs, PCs, PGs, and Pls are effective biomarkers to identify PPH. The biomarkers are also useful to screen the early PPH diagnosis indication and to understand the PPH pathogenesis.

3.3. The Effective Management of Diagnostic Checkup to Overcome Postpartum Hemorrhage with Technology-based Instruments
Table 3. The Technology-based Checkup and Effective Management to Overcome Postpartum Hemorrhage

No.	Titles	Method	Sample	Intervention	Results
1.	Digital Postpartum Hemorrhage Management Device (DPHMD) *Derartu D. Tekela, Abeba G. Asmare, Birhan M. G., Christian A. Assegahegn, Kidist D. Wami, Hundessa D. Nemomssa and Gizeaddis L. Simegn,* 2019	In this project, the blood measuring system of blood loss was integrated with IV liquid transfers and the vital signs of the mothers.	Not applicable	(The Prototype of Digital Postpartum Hemorrhage Management Device)	The researchers made the prototype and examined the prototype from various works of literature. The researchers examined the instrument. The result showed the accuracy level was 91.28% and was effective in terms of cost and application.
2.	A novel subtype of atonic postpartum hemorrhage: dynamic computed tomography	Retrospective Study	The researchers took 60 women receiving CT scans for the	The dynamic evaluation of the CT scan was based on the bleeding characteristics (the	The researchers found a significant correlation between contras extravasation at an early stage with the importance of administering Transarterial Embolization, $p < 0.0017$.

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	evaluation of bleeding characteristics and the uterine cavity *Asami Ikeda, Eiji Kondoh, Yoshitsugu Chigusa, Haruta Mogami, Kyoko Kameyama Nakao, Aki Kido, Akihito Horie, Tsukasa Baba, Junzo Hamanishi & Masaki Mandai,* 2019		management of severe postpartum hemorrhage.	initial contrast extravasation) and the sizes of the uterine cavity. The researchers evaluated the characteristics of the XYZ coordinating system.	The presence of embolization predicted the arterial bleeding and the location along with the formation of the uterine cavity.
3.	Three-dimensional computerized tomographic angiography for diagnosis and management of intractable postpartum hemorrhage *Akihiro Takeda , Wataru Koike , Sanae Imoto , Hiromi Nakamura*, 2014	Retrospective Study	The researchers examined all PPH cases with 3D CT angiography, including ultrasonography checkups.	The 3D CT angiography could provide independent information for operators about	Vascular abnormalities in a detailed manner, both inside or outside the uterus. The tool could also detect whether the near organs were involved. The tool also required minimum invasion within an immediate period. The tool could identify rare incidents of vascular injuries, such as pseudo uterine artery aneurysm and arteriovenous fistula., with correct blood vessel autonomy. Thus, the tool is better than conventional angiography as an early diagnostic tool for patients with PPH at triage.

3.4. Discussion

Detecting the Hemorrhage and Measuring the Blood Loss with Modern Technology

The implementation of modern-technology based diagnosis could facilitate the health workers in detecting and estimating postpartum hemorrhage during the III and IV periods. Thus, the health workers could promote early detection of emergency postpartum states, such as blood loss of more than 500cc [7]. The measuring technologies, both modern and digital technologies, could decrease and prevent the risks of postpartum hemorrhage; and diagnose and improve the hemorrhage management. From various developed researches about the checkup process and postpartum hemorrhage management in a modern manner, the researchers could develop web-based connections to provide early detection and to make a decision within emergency state situations during the delivery process, postpartum hemorrhage, and infection [8].

From the articles, the diagnostic methods with modern technology could detect and estimate the amounts of postpartum hemorrhage. The method included a web-based partograph with digital technology implementation to provide immediate estimation [9]. The research is excellent innovative research in promoting early hemorrhage detection. Thus, the patients can receive immediate care from obstetricians that mostly rely on visual observations. However, the limitation of the developed instrument was the incapability to measure the amounts of blood loss differences although the instrument was effective, comfortable, and relevant to the data to make a clinical decision. This limitation happened because the web-based digital partograph was originally based on partograph-based computer development.

Zahra Abbaspoor & Leila Vaziri explain that a waist-bag collector is an accurate and immediate procedure to visually estimate blood loss and detect postpartum hemorrhage [10]. Tripop Lertbunnaphong et al. promoted similar research. They investigated the significant differences between postpartum hemorrhage blood loss, visual estimation, and objective measurement with under-buttock drapes. The results showed that under-buttock drapes were more accurate than the visual estimation method [11]. Liley G (2015) conducted clinical observation research with gravimetric. The researcher found excellent accuracy in visual estimation measurements promoted by health

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workers. The clinical research results also showed that gravimetric was effective to determine the correlation between blood loss and hemoglobin decrease. Thus, the results were more accurate. The applied method was easy to use and teach to medical workers. The method only needed simple instruments at hospitals. Thus, the medical workers could apply the method [12].

This method was also practicable for a low-human source of medical workers. The implementation of SAPHE Mat was useful to improve the estimated detection of blood loss during the delivery. The procedure included multiplying the amounts of saturated blood contact or partial contact by 50 mL. The researchers compared the visual EBL with the actual blood loss, calculated based on the difference between pre-used and post-used mats. This calculation determined the volume of the blood loss [13]. Thus, health workers could diagnose the postpartum hemorrhage immediately. This immediate postpartum hemorrhage detection could decrease the mortality and morbidity rates of mothers.

The article titled " Risk Scoring System for the Prediction of Postpartum Blood Loss over 300 mL at Chiang Rai Regional Hospital" found the implementation of the scoring form as the first clinical assessment was useful for early detection and diagnosis of PPH. The form had excellent sensitivity and specification to predict postpartum blood loss for more than 300 mL after vaginal delivery based on the applied strategy to early detect and diagnose PPH [14]. However, the form had some shortcomings. Some factors had higher scores. The health care providers must consider the characteristics and adjustments for pregnant women to apply this form. Besides that, each predictor and score total must confirm the prospectiveness of the cohort study.

The digital imagery applications to measure postpartum blood loss is an accurate and objective alternative. This new method must be supported by a standard of operational procedure to control the area of absorbency around the underpads. Besides that, the types of applied underpads as the standard measurement of spatial resolution becomes an important aspect to obtain optimum results for blood loss measurement. The early prevention and medication of postpartum hemorrhage with this system are more effective and efficient. Besides that, the dependency on a community with transportation to receive health services could be indirectly decreased. Thus, the implementation of this method could realize carbon-free development [15].

Identifying the Early Potency of Postpartum Hemorrhage

Postpartum hemorrhage becomes the factor of 14 million mortality rates in mothers. The prevalence of postpartum hemorrhage ranged from 6% to 10% in the world [16]. The main predictor of mortality rate due to postpartum hemorrhage encounters challenges, such as the diagnosis process and the immediate intervention. Heretofore, the postpartum hemorrhage diagnosis methods have been relying on blood loss estimation. This technique has lower predictive capability and accuracy. With the Metabolomics study, a relatively new study could identify the biomarkers of some diseases, such as *Genomics, Transcriptomics,* and *Proteomics.* The study can also predict postpartum hemorrhage. This research provides meaningful efforts to screen the indicators of early postpartum diagnosis and to understand the pathogenic characteristics [17].

The Technology-based Checkup and Effective Management to Overcome Postpartum Hemorrhage

Recently, the implementation of Computed Tomography becomes the preferred model to evaluate hemorrhage incidents within emergency state situations. Akhiro Takida et al. found that 3D CT angiography provides independent information about vascular abnormality inside and events outside of the uterus. Thus, this device, 3D CT angiography, is better than conventional angiography as an early detector for triage patients with PPH diagnosis to treat the causes of hemorrhage. CT 3D angiography could provide adequate information about the areas of injuries[18]. The researchers also found similar results on CT dynamic evaluation and hemorrhage characteristics (the early stage of contras extravasation), and the uterine cavity sizes evaluated with XYZ coordinate system. The results showed a significant correlation between contrast extravasation at an early stage and the importance of transarterial Embolization, $p < 0.0017$. The presence of embolization predicted the arterial bleeding and the location along with the formation of the uterine cavity [19].

The study conducted by Derartu et al. about "Prototype Digital Postpartum Hemorrhage Management Device (DPHMD)" found the implementation of some measurements to predict blood loss and check the vital signs. In this case, the researchers were aware that the implementation of vital signs would not be accurate because of hemodynamic changes during the pregnancy. [20] The accuracy level reached a percentage of 91.28% with 5 literacies on 5 different subjects. The blood loss of this DPHMD was 98% accurate. This percentage is better than the visual prediction, 24-89% in many studies [11], [21], [22]. Thus, the instrument could facilitate obstetrician-gynecologists or obstetricians to estimate the blood loss and provide intravenous liquid accurately.

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4. CONCLUSION

Technology-based detections could early detect and facilitate postpartum hemorrhage and provide immediate care. High health field technology advancement facilitates the patients' care, health care service cost reduction, and health care worker scale improvement to help many people. The technology allows effective, immediate, accurate, controlled, easy, and zero paper care services. The results of this research are useful to promote further research about modern-technology-based models to detect and diagnose postpartum hemorrhage in islands.

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