Literature Review: Early Detection of Gestational Hypertension Using the Mean Arterial Pressure (MAP) Method

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Abstract

Gestational hypertension is a pregnancy complication that contributes to increased maternal and perinatal morbidity and mortality. Early detection is necessary to prevent complications such as preeclampsia and preterm birth. Mean Arterial Pressure (MAP) is a simple screening method that more accurately reflects organ perfusion. This study aims to examine the role of MAP as a predictor of gestational hypertension. This literature review was conducted by searching for published results in the Google Scholar, ProQuest, and PubMed databases between 2021 and 2026 using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method. The keywords used are early detection, gestational hypertension, and Mean Arterial Pressure. A literature review identified 17 sources that met the inclusion criteria. The conclusion is that measurement of Mean Arterial Pressure (MAP) is an effective diagnostic method for detecting the risk of gestational hypertension and preeclampsia as early as the first trimester of pregnancy. This measurement is also easy to perform, inexpensive, and easily implemented in healthcare facilities for widespread screening of the pregnant population. MAP measurement also has limitations in terms of sensitivity and specificity, so it needs to be combined with other parameters to improve predictive accuracy. MAP measurement is most effective when combined with the following assessments: 1) Biomarkers, such as sFlt-1/PlGF (soluble fms-like tyrosine kinase-1/placental growth factor) and PAPP-A (pregnancy-associated plasma protein A), 2) Doppler ultrasound of the uterine arteries, 3) the pregnant woman's clinical history. MAP testing should be implemented in a standardized manner as part of routine screening during antenatal care visits, particularly in during the first trimester of pregnancy and repeated in the second trimester.

Introduction

One of the Sustainable Development Goals (SDGs) aims to reduce the maternal mortality ratio (MMR) to less than 70 per 100,000 live births (WHO, 2024). The number of maternal deaths in Indonesia reached 4,129 in 2023 (BPS, 2024). The maternal mortality rate in Central Java reached 438 cases, with Pekalongan Regency recording 34 cases. Pekalongan Regency ranked second in Central Java for the highest number of maternal deaths in 2023. The prevalence of maternal mortality in Central Java decreased to 427 cases in 2024, with Brebes Regency ranking first with 54 cases and Pekalongan Regency ranking seventh with 18 cases. The causes of maternal mortality were hemorrhage, pregnancy-induced hypertension (30%), hemorrhage (15%), infection (5.6%), post-abortion complications (0.7%), and others (48.2%). (Dinkesprov Jateng, 2024). One of the causes of maternal mortality is preeclampsia. Preeclampsia is a condition characterized by elevated blood pressure that develops after 20 weeks of pregnancy, accompanied by rapid weight gain due to fluid retention and the presence of protein in the urine (Agustina et al., 2022). The prevalence of preeclampsia is estimated at

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2–8%, and it is projected to cause 46,000 maternal deaths and 500,000 infant deaths worldwide in 2024 (WHO, 2025). The prevalence of maternal deaths due to preeclampsia in Indonesia stands at 410 cases, with 27 cases (6.6%) in Central Java (Kemenkes RI, 2023). There were 164 cases of preeclampsia in Pekalongan Regency (4%), with 2 maternal deaths due to preeclampsia (1.22%) (Dinkeskab. Pekalongan, 2024).

The main cause of preeclampsia is gestational hypertension. Gestational hypertension is characterized by a systolic blood pressure of ≥ 140 mmHg and a diastolic blood pressure of ≥ 90 mmHg without proteinuria at 20 weeks of gestation, or an increase of 30 mmHg in systolic blood pressure or 15 mmHg in diastolic blood pressure above normal levels (Siregar et al., 2024). Gestational hypertension is generally not accompanied by proteinuria or signs of organ damage. If left untreated or not treated promptly, gestational hypertension can progress to preeclampsia (Pusparini et al., 2021). The etiology of gestational hypertension includes changes in the placental blood vessels, impaired endothelial function, immunological factors, and genetic factors. Other risk factors for gestational hypertension include first-time pregnancy, pregnancy at ages under 20 and over 35, obesity, multiple pregnancies, a history of hypertension, and a history of kidney disease and diabetes mellitus (Sri et al., 2021). Gestational hypertension can have serious consequences for both the mother and the fetus. For the mother, these include an increased risk of developing preeclampsia, organ damage (kidneys, liver, brain), and complications during childbirth (risk of preterm birth and increased risk of cesarean section) (Sri et al., 2021).

Early detection of gestational hypertension can be performed more accurately using the Mean Arterial Pressure (MAP) test, Doppler Uterine Artery (DUA) ultrasound, biomarker testing (Placental Growth Factor/PIGF and sFlt-1), and PAPP-A (pregnancy-associated plasma protein A) (Garovic et al., 2022). These screening methods are used in combination to improve the accuracy of predicting gestational hypertension. MAP and DUA assess hemodynamic status and blood flow, while biomarkers and PAPP-A evaluate placental function biochemically. This combination enables early detection before clinical symptoms appear. Mean Arterial Pressure (MAP) is the average arterial blood pressure over one cardiac cycle (Hurrell et al., 2022). MAP is used to detect elevated blood pressure early in pregnancy and serves as an early indicator of impaired perfusion (blood flow); high MAP values in the first trimester are associated with an increased risk of preeclampsia. Uterine Artery Doppler (UAD) is a Doppler ultrasound examination used to assess blood flow in the uterine arteries (Wu & Xu, 2025). UAD is used to assess blood flow resistance to the placenta and detect abnormalities in placental blood vessel formation (remodeling). If resistance is high or "notching" is present, the risk of preeclampsia and fetal growth restriction increases. Biomarkers (PlGF and sFlt-1) are blood tests for substances related to blood vessel formation (angiogenesis).

The PlGF test is used to assess placental blood vessel formation, where low PlGF levels indicate impaired placental function (Gunderson et al., 2023a). The sFlt-1 (soluble fms-like tyrosine kinase-1) test has anti-angiogenic properties (inhibiting blood vessel formation); high sFlt-1 levels are associated with preeclampsia. PAPP-A (Pregnancy-Associated Plasma Protein A) is a protein produced by the placenta and is typically tested during the first trimester. This test is used to assess early placental function. Low PAPP-A levels are associated with an increased risk of preeclampsia, fetal growth restriction, and other pregnancy complications (Ozkan et al., 2023). Research by Sanyal et al (2024) shows that the combination of serum biochemical markers (Free ß HCG, PAPP-A, PlGF) and biophysical markers (MAP and UAD) is the best screening test for predicting the overall risk of gestational hypertension, with a sensitivity of 97.37% and a specificity of 38.98% ($p < 0.0001$). Based on these findings, the author is interested in examining the current state of early detection of gestational hypertension using the Mean Arterial Pressure (MAP) method through a literature review.

Methods

This literature review employs the Literature Review (LR) method, which involves a systematic and clear analysis of existing research data through the collection, identification, and evaluation of such data. The purpose of this literature review is to investigate the early detection of gestational hypertension using the Mean Arterial Pressure (MAP) method. The literature review process was conducted by searching electronic databases such as Google Scholar, ProQuest, and PubMed. The research was limited to articles published between 2021 and 2026. The keywords used by the author were "early detection," AND "gestational hypertension," AND "Mean Arterial Pressure."

The inclusion criteria established in this literature review process are: 1) articles focusing on the early detection of gestational hypertension using the Mean Arterial Pressure (MAP) method in Indonesia and worldwide; 2) full-text articles published between 2021 and 2026; 3) articles written in Indonesian or English; 4) research articles. Exclusion criteria: 1) Articles in the form of theses or dissertations, 2) articles that are not freely accessible. Journal selection in this literature review utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method, presented in the following diagram:

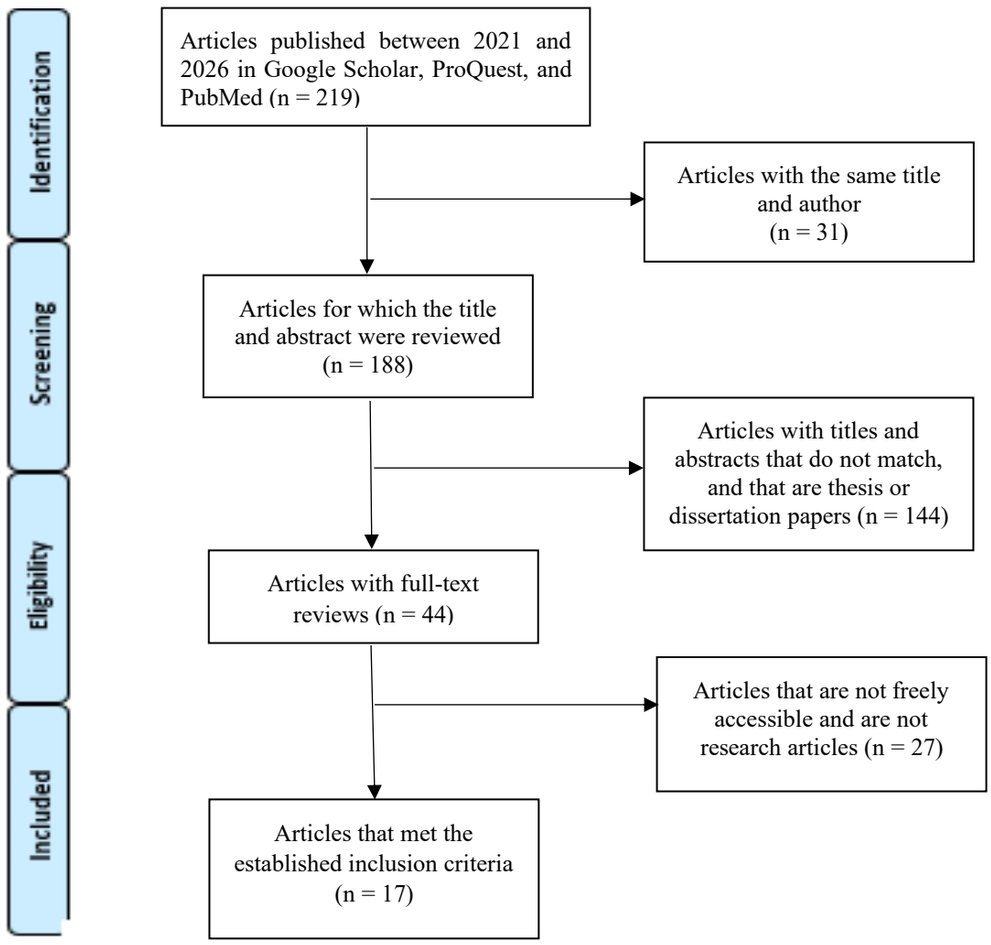

Figure 1. Literature Review Flowchart Using the PRISMA Method

Results and Discussion

A literature review was conducted on 15 articles. The articles were published between 2021 and 2026. The results of the journal analysis are presented in Table 1 as follows:

Table 1. Results of Journal Analysis

No	Research	Method	Results
1.	Mean arterial pressure for predicting preeclampsia in Asian women: a longitudinal cohort study Zhu et al (2021)	A prospective cohort study. There were 926 respondents who were pregnant with a single fetus and were less than 14 weeks pregnant	The study results showed that 20 pregnant women with preeclampsia had significantly lower levels of PlGF, as well as higher levels of the sFlt-1/PlGF ratio (soluble fms-like tyrosine kinase-1/placental growth factor) and MAP during pregnancy compared to women without preeclampsia. Compared with angiogenic factors and UtA-PI, MAP had a significantly higher area under the receiver operating characteristic curve (AUC) for predicting preeclampsia and long-term preeclampsia during pregnancy. For predicting preeclampsia, MAP had an AUC of 0.86 (95% CI 0.78 to 0.95), 0.87 (95% CI 0.80 to 0.95), and 0.91 (95% CI 0.85 to 0.98) at 11–14, 18–22, and 28–32 weeks of gestation, respectively. To predict preeclampsia in full-term pregnancies, MAP yielded an AUC of 0.87 (95% CI 0.75 to 0.99), 0.87 (95% CI 0.76 to 0.98), and 0.90 (95% CI 0.80 to 0.99) at 11–14, 18–22, and 28–32 weeks, respectively. For predicting preterm preeclampsia, the performance of MAP and PlGF was similar.

2.	Mean Arterial Pressure and the Endothelin-1 Levels in Preeclampsia Kristine et al., (2021)	cross-sectional study with a case-control design. pregnant women with a gestational age of more than 20 weeks (the case group consisting of 37 pregnant women with preeclampsia and the control group consisting of 53 pregnant women with normal blood pressure).	The results of the study showed that the mean serum ET-1 levels in preeclampsia were higher than in normotension, with a significant p-value of 0.001 ($p < 0.05$). MAP in preeclampsia was also higher than in normotension, with a significant p-value of 0.001 ($p < 0.05$), and there was a positive correlation between ET-1 and MAP with $r = 0.34$ and a p-value of 0.001 ($p < 0.05$).
3.	Role of Mean Arterial Pressure in Mid-trimester Pregnancy for the Prediction of Gestational Hypertension and Pre-Eclampsia Shanker & Gupta (2021)	A prospective cohort study. 316 pregant women with normotension	The performance of MAP for predicting the GH and PE was found to be very good. The area under the receiver operating characteristic (AUROC) for GH was 0.892 with sensitivity and specificity of 84.2 and 84.9%, respectively, whereas the AUROC for PE was 0.948 with sensitivity and specificity of 83.3 and 84.9%, respectively. MAP in the second trimester of pregnancy can be used to triage women with low-risk pregnancy for pregnancy hypertension
4.	The Effect of Assessment Mean Arterial Pressure and Body Mass Index as an Early Detection of Pre-Eclampsia Lushinta et al., (2022)	combines two cross-sectional and prospective cohort time approaches. Sampling technique with Accidental Sampling. 50 pregnant women aged over 20 weeks with normotension	indicate that there is an effect of MAP and BMI assessment with the incidence of Pre-Eclampsia and Eclampsia with a value (p-value = 0.000 < = 0.05).
5.	Screening for Preeclampsia in Pregnant Women Using Mean Arterial Pressure Destiyani & Diniyah (2023)	A descriptive-analytical study using a cross-sectional design. The sampling technique used was accidental sampling. There were 42 pregnant women who underwent checkups in May–June 2022	The study found that 73.8% of pregnant women had positive MAP test results, putting them at high risk of developing preeclampsia during pregnancy.
6	Early Prediction of Hypertensive Diseases of Pregnancy by Using Combined Screening Methods in a Rural Population Razzak & Shivkumar (2023)	prospective observational study of longitudinal. 513 pregnant women in their first trimester who underwent examinations.	The results of the study indicate that risk factors for gestational hypertension among maternal characteristics include advanced maternal age (>35 years), the presence of generalized edema, and proteinuria, along with MAP, uterine artery pulsation index (UtA-PI), and PAPP-A. The predictive accuracy of the combination of MAP, UtA-PI, and PAPP-A (pregnancy-associated plasma protein A) was also significant. We also found a significant increase in cesarean sections and NICU admissions among patients with hypertension. The combination of screening parameters, including MAP, UtA-PI, and PAPP-A, is effective for predicting early-onset hypertension in pregnancy
7	The Correlation Between Mean Arterial Pressure (MAP) Examination and The Incidence of Preeclampsia Sulistiawati et al., (2024)	A quantitative study using a case-control design and a retrospective approach. Pregnant women who underwent antenatal care (ANC)	There is a significant correlation between MAP measurements and the incidence of preeclampsia (p-value = 0.000)

		examinations: 66 respondents (33 in the case group and 33 in the control group).	
8	A Comparison of Mean Arterial Pressure (MAP) and Urinary Protein Levels for Preeclampsia Screening in Pregnant Women Zainiyah et al., (2024)	A descriptive study with a retrospective design. The sampling method used was simple random sampling. There were 210 pregnant women who underwent checkups between January and March 2023.	The study results showed that the majority were not at risk (88%), 137 women (65%) were multiparous, and 115 women (54.7%) were in their third trimester of pregnancy. The body mass index for obesity was 53.8%, and normal blood pressure was 95.1%; MAP ≥ 90 was 22%, and 6.68% of urine protein tests were positive.
9	Examination of Body Mass Index (BMI) & Mean Arterial Pressure (MAP) as Early Detection of Preeclampsia Rosyidah et al., (2024)	quantitative study using a case-control design. 100 respondents who are in their third trimester of a normal pregnancy	There is an association between Body Mass Index (BMI) and Mean Arterial Pressure (MAP) and the occurrence of preeclampsia. The sensitivity and specificity of BMI are 86% and 4%, respectively, while the sensitivity and specificity of MAP are 100% and 76%, respectively.
10	Long-Term Predictors of Gestational Hypertension: Placental Growth Factor, Pregnancy-Associated Plasma Protein-A and Free Beta-Hcg Versus Mean Arterial Pressure and Uterine Artery Doppler Versus a Combination of Both: A Comparative Study Sanyal et al., (2024)	A prospective, observational cohort study. 97 primigravida pregnant women with a gestational age of 11 weeks to 13 weeks and 6 days	The study results showed that the mean age, maternal weight, height, and BMI of patients with gestational hypertension were 30 ± 5 years, 64.3 ± 12.5 kg, 155.8 ± 5.5 cm, and 26.4 ± 4.1, respectively. Of the three, Group C (combination: serum biochemical markers (Free ß HCG, PAPP-A, PlGF) and biophysical markers (MAP and UAD)) was the best screening test for predicting the overall likelihood of gestational hypertension, with a sensitivity of 97.37% and a specificity of 38.98% ($p < 0.0001$). A mild negative correlation was observed between PlGF levels and the severity of PIH ($p = 0.0382$). MAP and UAD can be easily integrated into the infrastructure of most hospitals.
11	The Relationship Between Mean Arterial Pressure and the Incidence of Preeclampsia Sari et al (2025)	A quantitative study using a case-control design and a retrospective approach. The case sample was selected using total sampling, while the control sample was selected randomly using simple random sampling based on odd-numbered medical records. Pregnant women who underwent antenatal care (ANC) examinations, totaling 60 respondents (30 in the case group and 30 in the control group).	There is a significant association between Mean Arterial Pressure and the incidence of preeclampsia in pregnant women (p-value = 0.000). Women with elevated MAP have a 15,167-fold higher risk of developing preeclampsia compared to those with normal MAP, with a correlation coefficient of 0.000 indicating a strong association.
12	Prediction of Pre-Eclampsia Based on Maternal Clinical Characteristics, Placental Growth Factor, Mean Arterial Pressure, First --Trimester Uterine and Ophthalmic Artery Doppler: A Prospective	observational cohort study. 368 primigravida pregnant women carrying a single fetus at 11 weeks to 13 weeks and 6 days of gestation	The study results showed that of the 368 women who participated, 311 completed the study, with 32 (10.3%) developing gestational hypertension. Significant risk factors included older maternal age ($p = 0.047$), increased BMI ($p = 0.006$), primiparity ($p < 0.001$), pre-existing diabetes ($p < 0.001$), chronic hypertension ($p = 0.001$), and a family history of gestational hypertension ($p < 0.001$). The MAP and PSV (Peak Systolic Velocity) ratios from OAD

	Observational Cohort Study Redishetty et al (2025)		(Ophthalmic Artery Doppler) were significantly higher in the gestational hypertension group. A screening model combining maternal factors and OAD achieved the highest predictive accuracy (AUC = 0.8324), with the combination of maternal factors, PSV ratio, and PLGF (Placental Growth Factor) yielding the highest detection rate (62.5%).
13	Mean Arterial Pressure at the First Prenatal Visit as an Early Predictor of Preeclampsia Waks & Oakes, (2025)	Retrospective cohort study. pregnant persons with a first prenatal visit by 16 weeks' gestation and delivered in our system from January 2021 to December 2022 of 2169 respondents	Of2169 patients, 230 (11%) developed preeclampsia. The optimalMAP cut- point for predicting preeclampsiawas 88.5mmHg. MAPoutperformed the USPSTF preeclampsia risk screening algorithm with respect to predicting this diagnosis, as evidenced by AUROC of 0.71 compared to 0.66 (X2 = 5.00, p = .025). Contrasted with a positive USPSTF risk screening, MAP predicted preeclampsia with slightly improved sensitivity (67 vs. 66%) and negative predictive value (95 vs. 94%), but marginally poorer specificity (65 vs. 67%) and positive predictive value (18 vs. 19%). Early pregnancy MAP is a modest predictor ofpreeclampsia and has somewhat improved characteristics as a screening test relative to the USPSTF risk screening algorithm.
14	Overview of Preeclampsia Incidence Based on Risk Factors in Pregnant Women in the Sumbersari Community Health Center Area Putri et al (2025)	descriptive observational with retrospective design. 41 pregnant women with preeclampsia	The results of this study found that the percentage of risk factors was 51.2%: age <20 or >35 years, 4.9%: nulliparity, 36.6%: pregnancy spacing >10 years, 56.1%: obesity before pregnancy, 41.4%: history of preeclampsia, 2.4%: multiple pregnancies, 7.3%: diabetes during pregnancy, 39%: chronic hypertension, and 100%: MAP >90 mmHg.
15	Combined Assessment of Placental Growth Factor, Uterine Artery Pulsation Index, and Mean Arterial Pressure for Predicting Preeclampsia Wu & Xu, (2025)	Retrospective cohort study. 332 pregnant women who underwent regular prenatal check-ups between 11 and 13+6 weeks of pregnancy	identified age, body mass index (BMI), pregnancy associated plasma protein-A (PAPP-A), MAP, UTPI, and PLGF as independent predictors of early pregnancy PE (all P<0.05). The AUC values for age, BMI, PAPP-A, MAP, UTPI, and PLGF were 0.660, 0.669, 0.749, 0.869, 0.781, and 0.943, respectively. The AUC of the combined MAP + UTPI + PLGF model was 0.990 (95% CI: 0.938-0.998), with specificity and sensitivity values of 83.98% and 98.80% respectively. Internal validation showed a mean absolute error (MAE) of 0.012, and the consistency index was 0.99 (95% CI: 0.983-0.997). The AUC for external validation of the prediction model was 0.975 (95% CI 0.955-0.995, P<0.001). Age, BMI, PAPP-A, MAP, UTPI, and PLGF were all effective predictors for early PE. Furthermore, the combined detection of high-risk factors (MAP, UTPI, PLGF) has a high predictive value for PE early in pregnancy.
16	Association Between Gestational Blood Pressure Trajectories and Postpartum Normotension Recovery in Hypertensive Disorders: Retrospective Cohort Study Liang et al., (2026)	Retrospective Cohort Study. 3162 women with HDP were obtained from the antenatal care and the postpartum follow-up information System.	Trajectories of SBP (systolic Blood Pressure), DBP (dyastolic Blood Pressure) and MAP (mean arterial pressure) during pregnancy were significantly associated with unrecovered BP at 6 weeks post-partum. For gestational hypertension, those with the high-consistent rise (adjusted relative risk [aRR] 2.493, 95% CI 1.093-5.689) and high-late surge SBP trajectories (aRR 4.535, 95% CI 1.884-10.917) were associated with a significantly increased risk of BP

			nonrecovery at 6 weeks post-partum. Similar associations were observed for DBP and MAP. For chronic hypertension with superimposed preeclampsia, women with high-late surge in SBP (aRR 2.792, 95% CI 1.081-7.214), DBP (aRR 4.043, 95% CI 1.327-12.324), or MAP (aRR 4.018, 95% CI 1.462-11.045) had a significantly increased risk of BP nonrecovery at 6 weeks post-partum. Among women with chronic hypertension, those with the high-consistent rise trajectories of SBP (aRR 2.557, 95% CI 1.256-5.207), DBP (aRR 3.862, 95% CI 1.673-8.913), and MAP (aRR 3.714, 95% CI 1.682-8.201) had a significantly increased risk of BP nonrecovery at 6 weeks post-partum. Among women with preeclampsia, only high-consistent rise SBP trajectory remained significantly associated with unrecovered BP post-partum (aRR 3.355, 95% CI 1.140-9.873). The high-consistent rise and high-late surge trajectories of SBP, DBP, and MAP in gestational hypertension started at similar initial levels and crossed at approximately 22 weeks of gestation.
17	Analysis of Risk Factors for Mean Arterial Pressure and Body Mass Index on the Incidence of Preeclampsia Sari et al., (2026)	Case-Control design. 62 pregnant women, divided into 31 Preeclampsia cases and 31 Non-Preeclampsia controls	The study results showed that 20 pregnant women with preeclampsia had significantly lower levels of PlGF, as well as higher levels of the sFlt-1/PlGF ratio (soluble fms-like tyrosine kinase-1/placental growth factor) and MAP during pregnancy compared to women without preeclampsia. Compared with angiogenic factors and UtA-PI, MAP had a significantly higher area under the receiver operating characteristic curve (AUC) for predicting preeclampsia and long-term preeclampsia during pregnancy. For predicting preeclampsia, MAP had an AUC of 0.86 (95% CI 0.78 to 0.95), 0.87 (95% CI 0.80 to 0.95), and 0.91 (95% CI 0.85 to 0.98) at 11–14, 18–22, and 28–32 weeks of gestation, respectively. To predict preeclampsia in full-term pregnancies, MAP yielded an AUC of 0.87 (95% CI 0.75 to 0.99), 0.87 (95% CI 0.76 to 0.98), and 0.90 (95% CI 0.80 to 0.99) at 11–14, 18–22, and 28–32 weeks, respectively. For predicting preterm preeclampsia, the performance of MAP and PlGF was similar.

Gestational hypertension is a condition of high blood pressure that develops in pregnant women after 20 weeks of gestation, with blood pressure readings of ≥ 140/90 mmHg, and is not accompanied by protein in the urine (proteinuria) or signs of other organ damage (Syafira, 2021). This condition is generally temporary and may resolve after childbirth; however, it requires close monitoring as it can progress to preeclampsia and does not immediately indicate organ dysfunction in the early stages (Aryani, 2024). The difference between gestational hypertension and preeclampsia lies in the severity of the condition. Preeclampsia is characterized by elevated blood pressure of ≥ 140/90 mmHg after 20 weeks of gestation, accompanied by proteinuria or signs of organ damage (impaired kidney, liver, or brain function, or thrombocytopenia). This condition is more dangerous and can progress to eclampsia (seizures). (Khairani & Pratiwi, 2023).

The etiology of gestational hypertension is not yet fully understood, but this condition is associated with the mother's body's inability to adapt to physiological changes during pregnancy. Pregnancy causes changes in the cardiovascular system as blood vessels dilate, resulting in decreased vascular resistance and stable blood pressure (Damayanty et al., 2024). This adaptive process does not function optimally in gestational hypertension. The mother's blood vessels do not dilate sufficiently, leading to increased vascular resistance and consequently elevated blood pressure (Ramadona et al., 2022). Dysfunction of the inner lining of blood vessels (endothelium) also causes an imbalance in the substances that regulate blood vessel dilation and constriction, resulting in a greater tendency toward vasoconstriction. This

condition can affect blood flow to the placenta, although it does not cause systemic damage as seen in preeclampsia. Risk factors for gestational hypertension include maternal factors, pregnancy-related factors, comorbidities, and lifestyle factors (Damayanty et al., 2024). Maternal factors include primigravida, pregnancy at ages < 20 and > 35, a history of hypertension, obesity, and a family history of hypertension or preeclampsia. Pregnancy-related factors include multiple pregnancies, as well as pregnancies that are too far apart or too close together. Comorbidities include kidney disease, diabetes mellitus, and autoimmune disorders. Lifestyle factors include a high-sodium diet, lack of physical activity, excessive stress, and smoking (Masyita et al., 2022).

Gestational hypertension has adverse effects on the health of both the mother and the fetus, especially if it goes undetected and is not properly managed. Although it does not initially cause organ damage, this condition still carries a risk of progressing to more serious complications (Santika et al., 2024). Gestational hypertension can increase the risk of preeclampsia, a more severe condition involving organs such as the kidneys, liver, and brain. Mothers are also at risk of placental abruption, which is the detachment of the placenta before the baby is born and can cause severe, life-threatening bleeding. Uncontrolled hypertension can progress to eclampsia, which is characterized by seizures (Iryaningrum et al., 2023). Mothers are also more susceptible to blood clotting disorders, stroke, and complications during childbirth such as postpartum hemorrhage. Gestational hypertension can also disrupt blood flow to the placenta, resulting in an inadequate supply of oxygen and nutrients to the fetus. This can lead to intrauterine growth restriction (IUGR), low birth weight, and premature birth (Saropah et al., 2022). Placental blood flow disorders can also lead to fetal distress and even fetal death. Gestational hypertension can lead to more serious conditions and threaten the safety of both mother and fetus, making early detection of gestational hypertension crucial. Regular blood pressure monitoring during pregnancy can prevent complications with early intervention, resulting in better pregnancy outcomes (Santika et al., 2024).

One method for early detection of gestational hypertension is measuring Mean Arterial Pressure (MAP). MAP is the average arterial blood pressure during one cardiac cycle. MAP is considered the best indicator for assessing organ perfusion pressure, which is how well blood flows to vital organs such as the kidneys, brain, and placenta. MAP better reflects the "effective pressure" that actually pushes blood into the tissues than systolic or diastolic pressure alone. The formula for calculating MAP = (Systolic + 2 × Diastolic)/3 (Nyoman et al., 2024). During the second and third trimesters of pregnancy, systemic vascular resistance decreases, resulting in a slightly lower MAP compared to non-pregnant levels. Normal MAP values during pregnancy are around 70–90 mmHg, often based on the physiological decrease of approximately 5–10 mmHg in early pregnancy, which then returns to near baseline in the final trimester. Persistently elevated MAP values during pregnancy can be a risk factor for gestational hypertension, preeclampsia, and impaired placental perfusion (Y. P. Sari et al., 2025). Research by Rosyidah et al., (2024) showed a relationship between Mean Arterial Pressure (MAP) and the incidence of preeclampsia, with the sensitivity and specificity of MAP being 100% and 76%, respectively. MAP was also considered more stable and clinically meaningful than standard blood pressure measurements. Standard blood pressure is a diagnostic feature with low sensitivity and specificity for differentiating the risk of preeclampsia (Rolnik et al., 2023). MAP is considered more representative of the entire cardiac cycle. Systolic pressure only reflects the contraction phase of the heart, while MAP encompasses both systolic and diastolic phases, making it more representative of actual hemodynamic conditions. MAP is also more apt to reflect organ perfusion. Organs do not "feel" peak pressure (systolic), but are more influenced by the continuous mean pressure. MAP is considered more accurate for assessing renal perfusion (urine output), cerebral perfusion, and placental perfusion during pregnancy. MAP is more stable against transient fluctuations (Ozkan et al., 2023). Systolic blood pressure fluctuates easily due to activity, stress, or pain, while MAP is more sensitive because it incorporates the longer-lasting diastolic pressure. MAP and organ perfusion are clinically important. A MAP value <65 mmHg in humans indicates a risk of organ hypoperfusion. A MAP that is too high or progressively increasing during pregnancy may indicate increased vascular resistance, a risk of impaired placental blood flow, and a risk of preeclampsia (Garovic et al., 2022). Research by Zainiyah et al (2024) showed that as many as 22% of pregnant women showed MAP values ≥ 90 (positive) and had a higher risk of experiencing preeclampsia.

Research by Destiyani & Diniyah (2023) also showed that 73.8% of pregnant women had positive MAP measurements, thus being at high risk of developing preeclampsia during pregnancy. MAP is a more representative blood pressure parameter than systolic blood pressure alone, because it reflects the average pressure that actually drives organ perfusion (Hauspurg et al., 2024). Monitoring MAP during pregnancy is important for early detection of vascular disorders and the risk of complications, such as preeclampsia and placental perfusion disorders. (Ozkan et al., 2023). Research by Sulistiawati et al (2024) showed a significant correlation between MAP testing and the incidence of preeclampsia. MAP can be used for early

detection of gestational hypertension. MAP is the average pressure in the arteries during one cardiac cycle, reflecting overall organ perfusion. Monitoring MAP during pregnancy is crucial because changes in blood pressure can indicate impaired maternal cardiovascular adaptation (Haas et al., 2022). Research by Kristine et al (2021) showed that MAP values in preeclampsia are higher than in normotensive pregnant women. A decrease in blood pressure from the first trimester to mid-pregnancy occurs in normal pregnancies due to vasodilation. However, in women at risk for gestational hypertension or preeclampsia, MAP tends to remain stable or increase from the first trimester. This indicates a disruption in the vascular adaptation process, including possible endothelial dysfunction and increased vascular resistance (Gunderson et al., 2023b).

MAP as a predictor of preeclampsia/gestational hypertension because changes in MAP can be detected earlier than other clinical symptoms, making it a useful early predictive tool. High MAP values in the first or early second trimester have been shown to correlate with an increased risk of gestational hypertension and preeclampsia (Gunderson et al., 2023b). Research by Zhu et al (2021) showed that MAP values in mothers with gestational hypertension and preeclampsia were higher during pregnancy compared to women without gestational hypertension and preeclampsia. MAP had AUC of 0.86 (95% CI 0.78 to 0.95), 0.87 (95% CI 0.80 to 0.95) and 0.91 (95% CI 0.85 to 0.98) at gestational ages 11–14, 18–22 and 28–32 weeks, respectively. The MAP value for predicting preeclampsia in full-term pregnancies was obtained with AUC of 0.87 (95% CI 0.75 to 0.99), 0.87 (95% CI 0.76 to 0.98), and 0.90 (95% CI 0.80 to 0.99) at gestational ages 11–14, 18–22, and 28–32 weeks, respectively. This indicates that MAP is an effective method for early detection of the risk of gestational hypertension and preeclampsia since the first trimester of pregnancy. Research by Sari et al (2025) showed a significant association between MAP and the incidence of preeclampsia in pregnant women. Mothers with a positive MAP had a 15.167 times greater risk of developing preeclampsia compared to those with a normal MAP.

The use of MAP values as a predictor for early detection of gestational hypertension and preeclampsia has the advantages of being non-invasive and easy to measure (only requiring routine blood pressure measurements), low cost, making it suitable for wide-ranging screening, and can be combined with other risk factors (maternal history, age, body mass index, etc.) to increase prediction accuracy (Haas et al., 2022). Early detection through MAP allows healthcare professionals to conduct closer monitoring of at-risk mothers, provide earlier preventive interventions (e.g., education, lifestyle modifications, or specific therapies as indicated), and reduce the risk of complications for both mother and fetus. MAP is useful as a simple initial screening tool, but its use has several limitations that should be considered. MAP has limited sensitivity and specificity. MAP is not completely accurate as a sole predictor (Rolnik et al., 2023). Not all women with high MAP will develop gestational hypertension or preeclampsia; on the contrary, some cases can occur in women with normal MAP. MAP values can also be affected by other conditions, such as stress or anxiety during the examination, physical activity before the measurement, body position, obesity, or other medical conditions. This can lead to inconsistent measurement results. Errors in blood pressure measurement (uncalibrated equipment, incorrect cuff size, incorrect technique) can affect MAP values, thereby reducing their reliability (Phan et al., 2023). MAP also only indicates elevated arterial pressure, but cannot distinguish whether the cause is preeclampsia, chronic hypertension, or another condition. Preeclampsia involves many complex mechanisms (such as placental and endothelial dysfunction), which cannot be explained by an elevated MAP alone (Zhu et al., 2021). This is why MAP testing needs to be combined with other parameters to improve predictive accuracy. MAP measurements are best combined with laboratory tests, biomarkers (e.g., PlGF), uterine artery Doppler ultrasound, and the mother's clinical history (Sulistiawati et al., 2024).

Early detection of gestational hypertension can be done more accurately using the MAP examination method, Doppler Uterine Artery (DUA), biomechanical examination (Placental Growth Factor/PIGF and sFlt-1), and PAPP-A (pregnancy-associated plasma protein A) (Garovic et al., 2022). These screenings are used together to improve the accuracy of predicting gestational hypertension. MAP and DUA assess hemodynamics and blood flow, while biomarkers and PAPP-A biochemically assess placental function. This combination allows for early detection before clinical symptoms appear. Uterine Artery Doppler (DUA) is a Doppler ultrasound examination to assess blood flow in the uterine arteries (Wu & Xu, 2025). DUA is used to assess resistance to blood flow to the placenta and detect abnormalities in placental blood vessel remodeling. High resistance or "notching" increases the risk of preeclampsia and fetal growth restriction. Biomarkers (PlGF and sFlt-1) are blood tests for substances related to angiogenesis. PlGF testing supports placental blood vessel formation, while low PIGF levels indicate impaired placental function (Gunderson et al., 2023a). The sFlt-1 (soluble fms-like tyrosine kinase-1) test is anti-angiogenic (inhibits blood vessels). High sFlt-1 levels are associated with preeclampsia. PAPP-A (Pregnancy-Associated Plasma Protein A) is a protein produced by the placenta and is usually tested in the first trimester.

This test serves to assess early placental function. Low PAPP-A levels are associated with an increased risk of preeclampsia, fetal growth restriction, and other pregnancy complications (Ozkan et al., 2023). Research by Sanyal et al (2024) showed that the combination of serum biochemical markers (Free ß HCG, PAPP-A, PlGF) and biophysical markers (MAP and UAD) was the best screening test to predict the overall chance of gestational hypertension with a sensitivity of 97.37% and a specificity of 38.98%. Research by Zhu et al (2021) showed that the performance of MAP and sFlt-1/PlGF (soluble fms-like tyrosine kinase-1/placental growth factor) has effectiveness for early prediction of the risk of gestational hypertension and preeclampsia. Research by Kristine et al (2021) also showed that there was a positive correlation between the results of ET-1 (Endothelin-1 Levels) and MAP examinations for early detection of gestational hypertension and preeclampsia. Research by Razzak & Shivkumar (2023) further explained that the combined predictive accuracy of MAP, UtA-PI, and PAPP-A (pregnancy-associated plasma protein A) was also significant for predicting early hypertension in pregnancy. MAP and Uterine Artery Doppler (DUA) are the easiest examination options to integrate into most hospitals' infrastructure for effective early detection of gestational hypertension and preeclampsia.

Conclusion and Suggestions

Mean Arterial Pressure (MAP) measurement is an effective diagnostic method for detecting the risk of gestational hypertension and preeclampsia from the first trimester of pregnancy. This measurement is also easy to perform, inexpensive, and easily implemented in health facilities for widespread screening of pregnant women. MAP measurement also has limitations in terms of sensitivity and specificity, so it needs to be combined with other parameters to improve predictive accuracy. MAP measurement will be better when combined with examinations of 1) Biomarkers, such as sFlt-1/PlGF (soluble fms-like tyrosine kinase-1/placental growth factor) and PAPP-A (pregnancy-associated plasma protein A), 2) Uterine artery Doppler ultrasound, and 3) Maternal clinical history. Early detection of gestational hypertension and preeclampsia with MAP has clinical implications for health workers to conduct closer monitoring of at-risk mothers, provide earlier preventive interventions (e.g., education, lifestyle modifications, or specific therapies as indicated), and reduce the risk of complications for the mother and fetus.

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