

PHYSIOLOGY OF BLOOD PRESSURE REGULATION

Central Blood Pressure: Current Evidence and Clinical Importance in Hypertensive Disorders during Pregnancy

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ABSTRACT

Hypertensive disorders complicate 5 to 10% of all pregnancies and hypertension is a major pregnancy complication associated with both fetal and maternal morbidity and mortality. Measurement of brachial blood pressure (BP) is a routine clinical assessment tool for management of various hypertensive disorders. Systolic pressure varies throughout the vasculature; aortic systolic pressure [or central blood pressure (CBP)] is actually lower than that of systolic BP in brachial artery. Central to peripheral pressure difference is highly variable among individuals. In various studies, it has been reported that CBP is a better predictor of cardiovascular events as compared with peripheral BP. Hypertensive disorders in pregnancy are associated with increased arterial stiffness indices, both during and after pregnancy leading to differences in central and peripheral pressures. In this article, the issues related to importance of CBP measurement for management of hypertensive disorders in pregnancy have been discussed.

Keywords: Central blood pressure, Eclampsia, Hypertension, Preeclampsia, Pregnancy-induced hypertension.

How to cite this article: Priyadarsini N, Singh SC, Goyal M, Mahapatra SC. Central Blood Pressure: Current Evidence and Clinical Importance in Hypertensive Disorders during Pregnancy. *Hypertens J* 2017;3(4):173-177.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Hypertensive disorders complicate 5 to 10% of all pregnancies, and hypertension is a major pregnancy complication associated with both fetal and maternal morbidity and mortality.¹ Pathophysiology of hypertensive disorders in pregnancy is multifactorial and may be contributed in part by hypoxia which leads to release of stress factors into maternal circulation, resulting in alterations in systemic vasculature.² Hemodynamics in pregnancy is different from those of general population. The changes

associated with healthy pregnancy are increase in heart rate, cardiac output, and intravascular volume as well as decrease in peripheral vascular resistance and arterial BP.^{3,4} These adaptive hemodynamic changes may be due to the influence of estrogen and increased activity of the local metabolites.^{5,6} In gestational hypertension, opposite events are observed like increase in peripheral vascular resistance, vasoconstriction, a decrease in intravascular volume, and increased reactivity of the maternal vascular bed to pressure factors, with subsequent increase in arterial stiffness, tone, and BP.^{7,8} Arterial BP in clinics is traditionally measured with the brachial cuff sphygmomanometer, due to its ease of measurement. Several randomized controlled studies have demonstrated that decreasing BP in hypertensive individuals with treatment or lifestyle modification leads to significant reduction in risk of adverse cardiovascular events.⁹

After the work of Scipione Riva-Rocci on sphygmomanometer in the late 19th century, physicians focused only on the pressure waveform peak (systole) and trough (diastole) and ignored the rest of the arterial pressure waveform. However, brachial BP has been a modality of choice for diagnosing and managing various hypertensive disorders due to its ease of measurement; however, it is a poor surrogate for aortic pressure or CBP, which is invariably lower than corresponding brachial values.⁹ Kroeker and Wood¹⁰ demonstrated that pressure wave in peripheries responds to central changes induced by Valsalva maneuver. Peripheral pulse pressure is higher than at the aortic level. This amplification results due to the reflection of the pressure wave from the peripheral vasculature.¹¹ The CBP is a better marker than brachial pressure in predicting future cardiovascular events.^{12,13} Moreover, antihypertensive drugs may have differential effect on CBP and peripheral BP.¹⁴ In the Conduit Artery Function Evaluation (CAFÉ) study, it has been found that CBP was associated with clinical outcomes more strongly than brachial BP.¹⁴ Thus, CBP could provide a better framework for understanding the hemodynamic changes associated with various diseased states. The CBP can now reliably be determined by noninvasive techniques in clinics and it is gaining greater acceptance as a better prognostic marker than brachial pressure in hypertensive patients.⁹ These observations regarding utility of CBP in general population and hypertensive

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individuals have been extrapolated for diagnosing and managing hypertensive disorders in pregnancy in several studies.¹⁵⁻²⁰

PHYSIOLOGICAL CONCEPT OF CBP

Though there is continuous variation of BP throughout the cardiac cycle, in clinical practice, only systolic and diastolic pressures are measured. Traditionally, these pressures are usually determined by brachial cuff sphygmomanometer in clinical practice.

Blood pressure thus determined peripherally is not the same as that at aortic level because as the pulse wave propagates from aorta to periphery, its characteristics change due to progressive increase in arterial stiffness and decrease in arterial diameter. As the pressure wave travels from the highly elastic central arteries to stiffer peripheral arteries, the upper portion of the waveform becomes narrower, the systolic peak becomes more prominent, and systolic pressure increases (Fig. 1).⁹

This pulse waveform is the result of a forward wave generated by left ventricle and a reflected backward wave from various points of obstruction in peripheral vasculature.^{21,22} The magnitude of pressure amplification may be influenced by several demographic variables including age, gender, and height,²³ as well as clinical and physiological factors, such as hypercholesterolemia,²⁴ recreational stimulants,²⁵ vasoactive medications,²⁶ mean arterial pressure,²³ heart rate,²⁷ exercise,²⁸ and posture.²⁹

MEASUREMENT OF CBP

Direct measurement of CBP at aortic level is possible through cardiac catheterization, which was first demonstrated by Dr Werner Forssmann and was later used for diagnostic purposes by Cournand and Ranges.³⁰ Procedure for cardiac catheterization provided a way to directly assess the cardiopulmonary system, but for routine clinical use, this technique is highly invasive and may not be recommended. Fortunately, with recent advances in noninvasive assessment of BP, pressure waveform and advanced algorithms to predict CBP from it have rekindled the interest exploring the clinical utility of CBP. Most of the available noninvasive CBP measurement devices involve recording of pressure waveforms in vessels distal

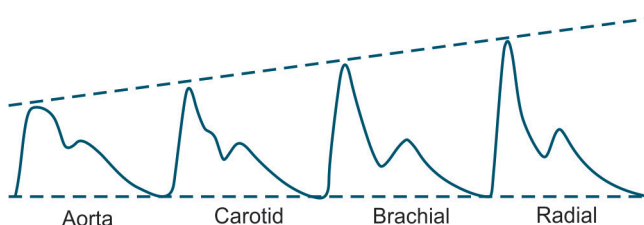


Fig. 1: Amplification of the pressure waveform moving from the aorta to the radial artery

to the aorta like carotid using applanation tonometry along with cuff BP measurement. Carotid artery tonometry, owing to its proximity to the aorta, is expected to be the most representative of the aortic pressure, but sometimes, it is difficult to record accurate waveforms particularly in obese individuals. Alternatively, pulse waves may be recorded from a peripheral artery like radial and brachial arteries by either tonometry or cuff BP and may be used to derive the central artery waveform for identification and analysis of late systolic shoulder and pressures using various algorithms or a generalized transfer function.³¹

The peripheral pulse pressure does not always provide a reliable measure of central pulse pressure. Though there is a considerable increase in pulse pressure from the aorta to the brachial artery, its degree is not constant, as it is influenced by age, posture, exercise, as well as heart rate, and BP value itself.²⁹ In addition, the estimate of CBP depends on late systolic shoulder in pulse waveform and may not be a true reflection of aortic BP in people with low BP.³²

Differences between central and peripheral BP may be clinically important because aortic pressure determines the left ventricular workload, rather than brachial pressure. Moreover, studies show that CBP is significantly related to cardiovascular events, and in addition, the effect of antihypertensive agents on BP seems to be different in brachial and aortic circulation.¹⁹ Provided the clinical utility of CBP, the increasing availability of CBP measuring devices and relative ease in using them, despite its limitations, are gaining acceptance in clinical practice.

IMPORTANCE OF CBP IN PREGNANCY

Heart disease is the leading cause of morbidity and mortality in women throughout the world.³³ Gestational hypertension is associated with increased arterial stiffness indices, both during and after pregnancy, contributing to the increased future cardiovascular risks.¹⁵ Cardiovascular events are more closely related to central than peripheral pressure because heart, kidney, and brain are exposed to aortic than brachial pressure. Moreover, it has been found that CBP is more closely correlated with widely accepted surrogate measures of cardiovascular risk, such as carotid intima media thickness³⁴⁻³⁶ and left ventricular mass,³⁶⁻³⁸ than brachial pressure in cross-sectional studies.

The potential value of CBP measurement has been further supported by several longitudinal studies. In the Research into Elderly Patient Anaesthesia and Surgery Outcome Numbers (REASON) Study, and in a substudy of The Anglo-Scandinavian Cardiac Outcomes Trial (ASCOT), the CBP turned out to be a better predictor for

adverse cardiovascular events as compared with brachial BP. Left ventricular mass also had stronger association with CBP compared with brachial BP.^{39,40}

The role and significance of CBP in diagnosing and managing hypertensive disorders in pregnancy are increasingly being realized. In the postpartum period in healthy women, while their brachial systolic BP was similar to those of nonpregnant controls, they have higher with smaller pulse pressure amplification. Physiologically, this is probably because of an increase in arterial stiffness and/or vasoconstriction resulting from the lack of influence of estrogens on the arterial wall in the first months after delivery.^{3-5,41-47} In recent studies, CBP, augmentation index, and pulse wave velocity have been reported to be higher in preeclampsia and gestational hypertension compared with normotensive pregnancies⁴⁸⁻⁵⁰ and it has been suggested that these parameters could be used to predict preeclampsia even as early as the 11th to 13th week of gestation.⁵¹ According to available data, CBP assessment showed significantly better sensitivity than the assessment of brachial BP parameters in pregnancy.¹⁶⁻²⁰ Szczepaniak-Chichel et al²⁰ reported that, in hypertensive pregnancies, the difference between aortic and peripheral BP was significantly smaller in the second and third trimester than in healthy pregnancy.

An important issue in preferring CBP over peripheral pressure in diagnosing and managing hypertensive disorders in pregnancy is defining cut-off values for CBP in such patients. It has been observed that reduced brachial systolic BP to aortic systolic pressure difference in hypertensive pregnancies may signify a narrower safety margin for complications²⁰ and can be taken into consideration in the management of pregnancy hypertension.

If CBP is effectively proved to be a better indicator for prediction and prognosis of hypertensive disorders in pregnancy, another issue will lie in effective and safe management of such cases. Several antihypertensive drugs usually prescribed currently may not effectively lower CBP as well as brachial cuff pressures. For example, beta-blockers have differential effect on aortic and brachial pressures. While they reduce peripheral BP, they are quite ineffective in reducing the CBP as well as adverse cardiovascular events.⁵²⁻⁵⁴ The only class of drugs found to be highly effective in reducing CBP are the vasodilators like nitrates. However, antihypertensive drugs which can be prescribed during pregnancy are limited and must be carefully studied for their effectiveness for lowering CBP as well.

CONCLUSION

The CBP appears to be a better predictor for hypertensive disorders in pregnancy apart from other adverse

cardiovascular events in general population. It would be interesting to witness the evolution of better techniques for determining CBP.

Before CBP can be prescribed as a standard clinical evaluation tool for management of hypertensive disorders in pregnancy, more data need to be generated and improvement in technique for determining CBP may be watched for. Pharmacological management of increased CBP needs to be further studied so that effective regimen can be developed for patients in general population as well as in pregnant women.

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