

Monitoring of Blood Pressure using Invasive or Non-invasive Method in Critically Ill Patients: A Review

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Abstract

Blood pressure is a core vital sign used as a basis for diagnosis and management of patients in critical care setting. Blood pressure (BP) can be monitored by both invasive and non-invasive methods. Invasive blood measurement using arterial access is considered the “gold” standard in critically ill patients. However, invasive methods put patient at risk of bleeding and infection as compared to non-invasive methods. Non-invasive blood pressure monitoring can be obtained through oscillometric or manual auscultatory sphygmomanometer. The objective of this review is to provide a global perspective of health care providers towards use of invasive or non-invasive method of measuring blood pressure. Both theoretical and existing clinical studies have suggested that non-invasive measurements may differ from invasive intra-arterial estimates of blood pressure.

***Keywords:* Blood pressure monitoring, comparison, invasive and non-invasive methods.**

Introduction

Blood pressure (BP) is a vital sign to monitor the hemodynamic status of critically ill patients. Clinical measurement of BP can be measured both invasively and non-invasively. The current use of automated digital sphygmomanometers is fairly reliable, safe and convenient for standard use and recommended by the American Society of Anesthesiologists to cycle every 5 min.¹ However, for any patient with multiple comorbidities, it is a frequent practice to place invasive monitoring devices. Blood pressure measured by invasive intra-arterial line is generally considered to be the gold standard in critically ill patients,^{2,3} but errors may be introduced by over- or under damping, calibration errors, and movement artefacts.^{2,4} In all other cases, intermittent non-invasive blood pressure monitoring is used for monitoring of blood pressure.⁵ Automated noninvasive blood pressure systems using oscillometric techniques have advantages over invasive arterial lines as they avoid bleeding and infection risk, and can be used outside the ICU.^{6,7} The Association for the Advancement of Medical Instrumentation-SP10 standard recommended by the Food and Drug Administration reports substantial differences between indirect non-invasive blood pressure and direct intra-arterial measurements.⁸

Nurses working in critical care setting need to recognize that blood pressure measurement technique chosen is appropriate and based on evidence. This review will focus on use of non-invasive oscillometric and invasive intra-arterial methods to find accurate and reliable method to determine blood pressure in critically ill patients.

Invasive Method of Measuring Blood Pressure

Blood pressure is accurately measured invasively through an arterial line. In this method, cannula is inserted into an artery, commonly radial, femoral or dorsalis pedis. It is helpful for beat-to-beat recording of blood pressure. The most common site is the radial artery due to ease of access, ease of actual cannulation and less rate of complications.⁹ The catheter is connected by a long, thin and liquid-filled tubing to a transducer, which records the transmitted blood pressure through the fluid column. The transducer needs to be kept horizontally level i.e. at the level of heart with the patient. Raising or lowering the transducer relative to the patient will alter the reading. Zeroing is important and is performed by opening the transducer at the level of

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heart to atmospheric pressure and electronically zeroing the system. The transducer translates the pressure changes into electrical signals displayed on a monitor. Although this method of direct measurement offers reliable and accurate measurements but it is associated with complications

such as bleeding, hematoma, arterial thrombosis, infection, accidental injection of intravenous drugs, nerve damage and even distal limb ischemia (table 1).¹⁰ Patients with invasive arterial monitoring require close supervision, as there is a danger of severe bleeding if the line becomes disconnected.

Temporary radial artery occlusion	15-18%
Hematoma	14.4%
Local infection	0.72%
Bleeding	0.50%
Sepsis	0.13%
Pseudoaneurysm	0.09%
Severe hand ischemia	0.09%

Table 1. Radial artery catheterization complications¹⁰

Oscillometric Method of Measuring Blood Pressure

Oscillometric method is the standard method for automated blood pressure measurement. The non-invasive oscillometric measurement is simpler and quicker than invasive measurements and requires less expertise. It is less painful for the patient. The complications associated with prolonged non-invasive blood pressure monitoring include ischemia and radial nerve palsy. The cuff is tied as in auscultatory method and blood pressure is recorded with electronic pressure sensor i.e. transducer. The cuff is inflated to a point above systolic blood pressure and slowly deflated while the presence of oscillations is detected by a pressure sensor.

These devices also have the advantage of taking repeated measurements at predetermined time intervals. Automation offers several advantages over manual techniques. Most importantly, clinician subjectivity is eliminated with the possibility of attaining repeatable results while saving clinicians' time it would have taken to obtain results manually.

Comparison of Invasive and Non-invasive Methods of Blood Pressure Measurement

Though there are advantages and disadvantages of each method, different studies have given varied results about the difference between blood pressure measured by invasive and non-invasive methods.

In a meta-analysis by Kim et al., 28 studies and 919 patients were included. They found that inaccuracy and imprecision of continuous non-invasive arterial pressure monitoring devices are larger than what was defined as acceptable. This may have implications for clinical situations where continuous non-invasive arterial pressure is being used for

patient care decisions.¹¹

Lehman et al. conducted a retrospective study comparing invasive arterial blood pressure and non-invasive blood pressure measurements using a large ICU database. They performed pairwise comparison between concurrent measures of invasive arterial blood pressure and non-invasive blood pressure. They concluded that clinically significant discrepancies exist between invasive and non-invasive systolic blood pressure measurements during hypotension.¹²

In a study done by Takci et al. twenty-seven premature infants with a mean birth weight of 1138 ± 552 g were enrolled in the prospective study. Invasive and non-invasive mean arterial pressure (MAP) levels were recorded simultaneously at each measurement in all patients. This study showed good agreement between oscillometric and invasive readings in critically ill premature infants. However, the accuracy of the oscillometric BP measurement technique fails in preterm infants with BP within the lower limits.¹³

In a prospective study by Jagadeesh et al., they compared the continuous non-invasive arterial pressure (CNAP) monitoring device with invasive arterial blood pressure (IAP) measurement in 30 patients in a cardiac surgical Intensive Care Unit (ICU). It was reported that the Bland Altman plot showed a uniform distribution and a good agreement of all arterial blood pressure values between CNAP and IAP. Percentage within limits of agreement was 94.5%, 95.1% and 99.4% for systolic, diastolic and MAP. They concluded that CNAP is a reliable, non-invasive, continuous blood pressure monitor that provides real-time estimates of arterial pressure comparable to those generated by an invasive arterial catheter system. CNAP can be used as an alternative to IAP.¹⁴

In a study by Wax et al., simultaneous measurements of ABP and NIBP made during non-cardiac cases were extracted from electronic anesthesia records; the differences were subjected to regression analysis. The result showed that non-invasive BP was generally higher than arterial BP during periods of hypotension and lower than ABP during periods of hypertension. The use of NIBP measurements to supplement ABP measurements was associated with decreased use of blood transfusions, vasopressor infusions, and antihypertensive medications compared with the use of ABP alone.¹⁵

Young et al. compared blood pressure measurement determined using continuous, non-invasive device with simultaneous invasive blood pressure measurements in 35 patients undergoing general endotracheal anesthesia. It was noted that the continuous non-invasive monitoring technique is not of sufficient accuracy to replace direct invasive measurement of arterial blood pressure, owing to relatively wide limits of agreement between the two methods.¹⁶

In a study done by Loubser, comparison of blood pressures measured by direct radial intra-arterial and indirect brachial automated oscillometric methods was performed in thirty hypertensive post-carotid endarterectomy patients. The results demonstrate that in the hypertensive pressure range, a significant difference exists in systolic pressure measured by intra-arterial and automated oscillometric methods.¹⁷

The authors also carried out a study to compare blood pressure measurement by invasive and non-invasive methods in patients on inotropic support and quantified the relationship of the number of inotropes to the bias of non-invasive measurement. The study concluded that non-invasive blood pressure measurement is not a reliable alternative to invasive intra-arterial measurement in patients receiving inotropes. The observed bias increases with the number of inotropes the patient is receiving.

Conclusion

From the review literature available, it can be concluded that non-invasive method does not give accurate and reliable reading of blood pressure in critically ill patients. Many of the studies demonstrated that significant difference exists between invasive and non-invasive methods of measuring the blood pressure, hence non-invasive method cannot be used as an alternative to invasive intra-arterial method in making clinical decisions.

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