ARAŞTIRMA MAKALESİ/ORIGINAL RESEARCH

DOI: 10.5505/ktd.2023.38455
KocaeliMedJ2023;12(1):135-142

Prematüre Bebeklerde İntraarteryel ve Osilometrik Kan Basıncı Ölçümünün Karşılaştırılması ve Karşılaştırmayı Etkileyecek Faktörlerin Belirlenmesi

Comparison of Intraarterial and Oscillometric Blood Pressure Measurement in Premature Newborns and Determination of Factors Affecting the Comparison

Nagihan İskender[1], İbrahim Murat Hirfanoğlu[2], Canan Türkyılmaz[2], Esra Önal[2], Ebru Ergenekon[2], Esin Koç[2], Yıldız Atalay[2]

1Gazi Üniversitesi Tıp Fakültesi, Çocuk Sağlığı ve Hastalıkları Anabilim Dalı, Ankara, Türkiye

2Gazi Üniversitesi Tıp Fakültesi, Çocuk Sağlığı ve Hastalıkları Anabilim Dalı, Neonatoloji, Ankara, Türkiye

ÖZET

GİRİŞ ve AMAÇ: Yenidoğan yoğun bakım ünitelerinde (YYBÜ) sıklıkla kullanılan osilometrik yöntem ile elde edilen kan basıncı değerlerinin intraarteryel ölçüm değerleriyle korele olup olmadığı tartışma konusudur. Biz bu çalışmada intraarteryel ve osilometrik yöntemlerle ölçülmüş sistolik (SKB), diyastolik (DKB) ve ortalama (OKB) kan basıncı değerlerinin karşılaştırılmasını; karşılaştırma sonucunda anlamlı fark bulunması durumunda hangi parametrelerin bu farklılığa neden olduğunun belirlenmesini hedefledik.

YÖNTEM ve GEREÇLER: Prospektif olan bu çalışmaya, izleminde umbilikal arter kateterizesyonuna gerek duyulan 20 prematüre bebek (gebelik haftası 25-37 hafta olan) dahil edildi. Beş gün boyunca eş zamanlı intraarteryel ve osilometrik yöntemlerle ölçülmüş 400'er sistolik, diyastolik ve ortalama kan basıncı değerleri, eş zamanlı aldığı ilaç tedavisi (inotrop, sedatif), solunum desteği, beslenme durumu, gebelik haftası, doğum ağırlığı, kol çevresi, anne yaşı, surfaktan alıp almadığı, eritrosit desteği,fototerapi alıp almadığı, sepsis varlığı, antenatal risk faktörleri kaydedildi.

BULGULAR: Osilometrik SKB, intraarteryel SKB'ye göre 2.61±6,84 mmHg anlamlı daha yüksek (p<0,001); osilometrik DKB intraarteryel DKB'ye göre -2,41±7,94 mmHg anlamlı daha düşük ve osilometrik OKB intraarteryel OKB değerlerinden -3,02±6,84 mmHg anlamlı daha düşük (p<0,001) olarak saptanmıştır. Osilometrik ve intraarteryel yöntem arasındaki farklılığı etkileyen bağımsız değişkenler; SKB için sedatif kullanımı (p=0,02 R^2=0,33), DKB için inotrop alımı (p=0,001), gebelik haftası (p=0,005), vücut ağırlığı (p=0,001) ve surfaktan alımı (p=0,014) olarak belirlenmiştir. OKB'yi etkileyen bağımsız değişken bulunmamıştır.

TARTIŞMA ve SONUÇ: Osilometrik yöntem ile intraarteryel yöntem arasında anlamlı istatistiksel farklılık bulunmuştur. Genel durumu kötü, hasta yenidoğanlarda umbilikal kateterizasyon aracılıklı kan basıncı ölçümü tercih edilmelidir.

Anahtar Kelimeler: prematüre, osilometrik, intraarteryel, kan basıncı

ABSTRACT

INTRODUCTION: It is a matter of debate whether the blood pressure values obtained by the oscillometric method, which is often used in neonatal intensive care units (NICU), correlate with intraarterial values. We aimed to compare systolic (SBP), diastolic (DBP) and mean (MBP) blood pressure values measured by intraarterial and oscillometric methods;to determine which parameters cause difference if there is a significant difference.

METHODS: This prospective study included 20 premature newborns who were required umbilical artery catheterization during follow-up. 400 systolic, diastolic and mean blood pressure values that are simultaneously measured by intraarterial and oscillometric method for five days and also simultaneous received medication (inotrope, sedative), respiratory support, nutritional status, gestational age, birth weight, arm circumference, surfactant, erythrocyte support, phototherapy intake, sepsis, the presence of antenatal risk factors, vital signs, sleep-wake status were recorded.

RESULTS: Oscillometric SBP was significantly higher than intraarterial SBP by 2.61±6.84 mmHg (p<0.001), oscillometric DBP was significantly lower by -2.41±7.94 mmHg compared to intraarterial DBP, and oscillometric MBP was significantly lower by -3.02±6.84 mmHg than intraarterial MBP values (p<0.001).Independent variables affecting the difference between oscillometric and intraarterial methods were sedative use for SBP (p=0.02 R2=0.33), inotrope intake, gestational week (p=0.005), body weight (p=0.001) and surfactant intake (p=0.014) for DBP (p=0.001).There were no independent variables affecting MBP.

DISCUSSION AND CONCLUSION: A statistically significant difference was found between the oscillometric and the intraarterial method. Blood pressure measurement via umbilical catheterization should be preferred in sick newborns with poor general condition.

Keywords: premature, oscillometric, intraarterial, blood pressure

Kabul Tarihi:14.03.2023

Correspondence: Uzm. Dr. Nagihan İskender, Gazi Üniversitesi Tıp Fakültesi, Çocuk Sağlığı ve Hastalıkları Anabilim Dalı, Ankara, Türkiye
E-mail:nyildiz1983@yahoo.com

INTRODUCTION

Blood pressure measurement is an important clinical indicator in neonatal intensive care units (NICU), especially in critically ill premature newborns (1). It is desirable that the method to be used for blood pressure measurement should be simple, reliable, non-invasive, painless and capable of continuous measurement. However, such a measurement technique has not yet been found (2). Blood pressure measurement techniques in premature newborns generally include noninvasive cuff mediated or invasive arterial catheter-mediated measurement techniques. Although doppler, oscillometric, palpation, sphygmomanometer blood pressure measurements are noninvasive measurement techniques, noninvasive measurement methods other than oscillometric technique are not practical and reliable in many patients (1).

The oscillometric method is often used in NICU due to its practicality. However, international studies conducted in terms of the reliability and accuracy of the oscillometric method still give controversial results (1,3).

Although invasive arterial blood pressure measurement is the most reliable method in critically ill premature newborns; it may not be possible to apply to every newborn due to reasons such as bleeding, infection, thrombus formation, vasospasm (4,5).

The necessity and reliability of which blood pressure measurement to use in premature newborns is a matter of debate (2). Whether oscillometric measurements are correlated with intraarterial measurement values is still a topic of discussion. There are many studies conducted on this subject. Some of these studies found a good correlation between these two methods, although the reliability of the oscillometric method was found to be questionable at low birth weight and hypotensive values in some studies (6,7,8,9).

There is not a multidimensional study that found the variables such as respiratory support, antenatal and postnatal drug therapy, the medical history of mother such as diabetes, preeclampsia, hypertension that affect the invasive and non-invasive measurement other than these two methods.

In this study, we aimed to compare intraarterially and oscillometrically measured systolic (SBP), diastolic (DBP) and mean (MBP) blood pressure values of 20 premature newborn who had umbilical catheter during follow-up. In case a significant difference is found as a result of the comparison, we also aimed to determine which parameters cause this difference.

MATERIAL AND METHODS

20 premature newborns (with gestational age between 25-37 weeks) who were born in Gazi University Faculty of Medicine Hospital, admitted to NICU, and required umbilical artery catheterization during follow-up were included in this single-center, prospective study by obtaining informed consent from their families. Premature newborns with congenital or chromosomal anomalies, arrhythmia due to congenital heart disease and heart failure, whose umbilical catheter was removed before 5 days, and newborns whose parents volunteering ended were excluded from the study.

The study was approved by the Ethics Committee of Gazi University on 11.11.2013 with the approval number of 186.

In the study, blood pressure values were measured simultaneously by oscillometrically and intraarterially at 6-hour intervals for five days. During these measurements, medical treatment (inotrope, sedative), vital signs (fever, respiratory rate, peak heart rate), respiratory support, nutritional status, sleep-wake status of patient were recorded simultaneously.

Mechanical ventilation and CPAP/nasal intermittent forced ventilation (IMV) support were accepted as respiratory support.

For each patient, gestational age, birth weight, arm circumference, inotrope-sedation-surfactant therapy, erythrocyte support, phototherapy, respiratory support, nutritional status, presence of sepsis, antenatal risk factors such as use of antenatal steroids, gestational diabetes mellitus (GDM)/ diabetes mellitus (DM), hypertension/preeclampsia history of mother, maternal smoking status, vital signs, sleep-wake status were recorded.

A 3 F Vygon catheter was used for umbilical catheterization in patients < 1000 g and 3.5 F Vygon catheter was used in patients ≥1000 g. All of the catheters were placed with high placement. The catheter patency was maintained with heparinized isotonic NaCl solution (0.5

ml/h). İntraarterial measurements were performed by connecting the arterial extension to the Dinamap transducer (GE Medical System Inf., Milwaukee, Winconish, USA). The system was calibrated when the dichrotic pulse was impaired, or blood / air bubbles were observed in the system, or every 12 hours.

Oscillometric measurements were made via Dinamap (GE Medikal Sistems Inf., Milwaukee, Winconish, USA). Measurements were made while the patient was calm, not crying, avoiding any attempts within the first 30 minutes. Not a single limb has been identified for measurements. The lower and upper extremities or the right/ left extremities were used randomly. The appropriate cuff size was used as recommended by the manufacturer.

Oscillometric and intraarterial measurements were recorded by measuring simultaneously and one time. 400 oscillometric and 400 intraarterial diastolic, mean and systolic blood pressures were recorded simultaneously. The obtained datas were evaluated with the SPSS 16.0 package program.

For statistical analysis, Pearson correlation coefficient was used to determine the relation between oscillometric and intraarterial measurements in all three groups. The Bland Altman method was used to compare the mean, diastolic and systolic blood pressure values determined by two measurement methods. To assess if differences in the coefficient of variation of the measurements were statistically significant, the paired samples t-test was used.

The demographic characteristics of the patients were indicated as mean ± standard deviation (minimum value – maximum value). Gestational week, birth weight, inotrope-sedation use treatment, respiratory support, nutritional status status [(minimal enteral nutrition +total parenteral nutrition (TPN), TPN)], arm circumference, surfactant intake, presence of sepsis, antenatal steroid use, antenatal risk factors such as maternal smoking, GDM/DM, hypertension/preeclampsia history of mother, erythrocyte support, phototherapy intake, vital signs, sleep-wake status were examined by using multiple linear regression method whether they have an effect on the difference of the methods.

The statistical significance value was accepted as $p<0.05$.

RESULTS

During the study period, 101 premature newborns were admitted to the NICU, and 20 premature newborns who fully met the criteria were included into the study.

Demographic characteristics of the patients and antenatal risk factors are in (Table 1).

According to the study protocol, 400 oscillometric and 400 intraarterial diastolic, mean and systolic blood pressure values were recorded simultaneously. A moderate Pearson correlation was found for oscillometric and intraarterial DBP measurements (r=0.60), and a strong Pearson correlation was found for SBP measurements (r=0.78) and MBP measurements (r=70).

Difference between the averages of oscillometric and intraarterial systolic, mean and diastolic blood pressures were found statistically significant (p=0.001) (Table 2). Oscillometrically measured systolic pressures were found significantly higher than intraarterial systolic measurements; oscillometric diastolic and mean blood pressure values were significantly lower than intraarterial values.

The daily avareges of systolic measurements were found higher with the oscillometric method; the daily avareges of diastolic and mean blood pressures were found higher in intraarterial measurement for 5 days. In the oscillometric measurement, systolic, mean and diastolic blood pressure values increased day by day for 5 days. In intraarterial measurement, systolic, diastolic and mean blood pressure values increased during the first 3 days, fell below the 3rd day values on the 4th day and started to increase again on the 5th day (Figure 1).

According to Bland Altman analysis, there was no systematic difference between the averages of the oscillometric and intaarterial blood pressure values in all three measurements (Figure 2, Figure 3, Figure 4).

Accordingly, the parameter affecting the difference between oscillometric and intraarterial systolic measurements was the use of sedatives (p=0.02) and the use of sedatives increased the difference between the two methods by 2.88 mmHg. The parameters

affecting the difference between the diastolic measurements were inotrope intake (p=0.001), gestational week (p=0.005), body weight (p=0.001) and surfactant intake (p=0.014). Among these, the most determining factor is inotropic use, while the least determining factor is body weight. The use of inotropes further increased the diastolic difference between the two methods, and the use of surfactant reduced the difference. An increase in the gestational week caused an increase in the diastolic difference, while an increase in body weight reduced the difference. According to all these analyzes, no factor affecting the mean blood pressure difference was found.

Table 1: Demographic Characteristics of Patients

Gender (F/M) n (%)	13/7 (%65 / %35)
Mode of delivery (C/S / NSVY) n (%)	18/2 (%90 / %10)
Average birth weight, g	1832±1800 gr (745 - 3920)
Average week of pregnancy	32,8±6,4 (25 5/7 – 36 5/7)
Average maternal age, years	29±11 (21-36)
Maternal fertility status, n (%) (Primiparity/ multiparity)	9/11 (%45-%55)
Average arm circumference, cm	7,65±2,22 cm (6-10 cm)
Nutrition type (TPN/ TPN+minimal enteral nutrition) n (%)	8/12 (%40 / %60)
Inotropic support n (%)	12 (%60)
Sedation n (%)	10 (%50)
Surfactant requirement n (%)	9 (%45)
Respiratory support (MV/ CPAP/ MV+CPAP) n (%)	7/5/5 (%35 / %20 / %20)
Presence of sepsis n (%) (blood culture positivity for the first 5 days)	0
Erythrocyte requirement n (%)	5 (%25)
Treatment due to indirect hyperbilirubinemia n (%)	15 (%75)
Maternal hypertension n (%)	1 (%5)
Maternal preeclampsia n (%)	2 (%10)
Smoking status n (%)	1 (%5)
Presence of gestational diabetes n (%) (regulated with insulin)	3 (%15)
Antenatal steroid use n (%)	6 (%30)

Table 2. Comparison of Averages of Systolic, Diastolic and Mean Blood Pressure Values (mmHg) Measured by Intraarterial and Oscillometric Method

	Mean	Standard Deviation	EK	EB	t		P
Os (59,41) Cs(56,80)	**2,61**	**6,84**	1,94	3,29	7,64		**0,001**
Od(34,49) Cd(36,91)	**-2,41**	**7,94**	-3,19	-1,63	-6,07		**0,001**
Om(42,24) Cm(45,26)	**-3,02**	**6,84**	-3,69	-2,35	-8,83		**0,001**

Paired t Test (Os: oscillometric systolic blood pressure, Od: oscillometric diastolic blood pressure, Om: oscillometric mean blood pressure, Cs: intraarterial systolic blood pressure, Cd: intraarterial diastolic blood pressure, Cm: intraarterial mean blood pressure).

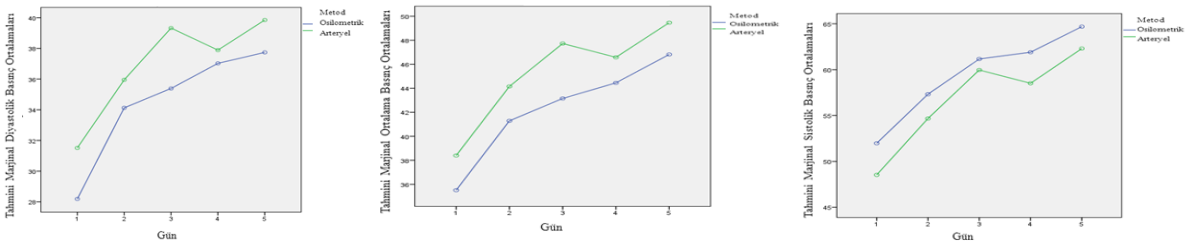

Figure 1. Changes in systolic, diastolic and mean arterial pressures over time measured by intraarterial and oscillometric methods.

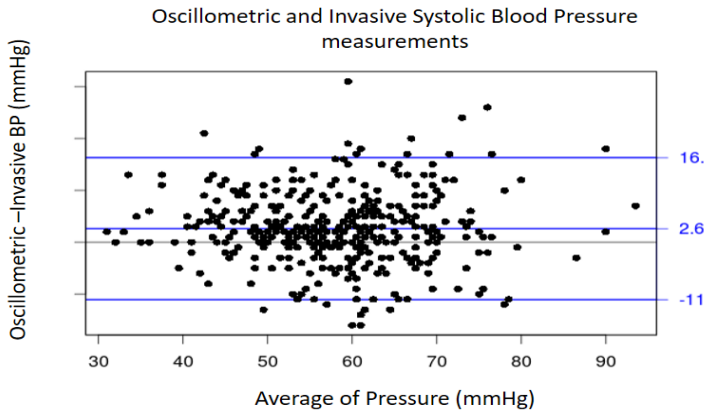

Figure 2. Bland Atman graph showing systolic blood pressure values (mmHg) measured by intraarterial and oscillometric method

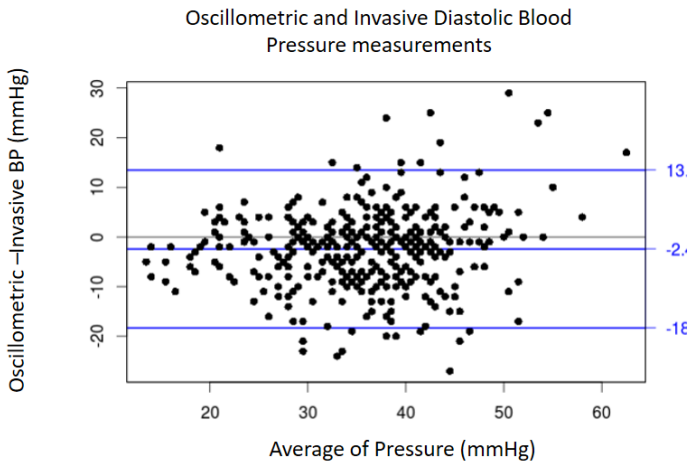

Figure 3. Bland Atman graph showing diastolic blood pressure values (mmHg) measured by intraarterial and oscillometric method

In the group whose gestational week was 32 weeks and below, the oscillometric method tended to measure DBP and MBP values further lower than the intraarterial method. However, there was no statistically significant difference between SBP (p=0.71) and MBP (p=0.15) values between the two measurement methods, while a significant statistical difference was found between the oscillometric method and the intraarterial method for DBP values (p= 0.049). In the group with an MBP value of 30 mmHg or less, the oscillometric method tended to measure higher at all three pressure values compared to the intra-arterial method. Statistically, in low blood pressure values, the oscillometric method measured SBP (p=0.03) and MBP (p=0.004) values significantly higher; no statistical difference was found in DBP values (p=0.16).

DISCUSSION

It is important to measure and monitor the blood pressure in sick newborns, especially in premature ones to recognize hypotension and hypertension which have an impact on the neurodevelopmental prognosis in the long term and to provide correct and adequate intervention (1,7,10,11).

The intraarterial method is accepted as the gold standard in blood pressure monitoring in NICU, especially in premature and sick newborns. However, today the oscillometric method has been used with increasing frequency (1).

There are cases where both methods give erroneous results. The invasive method can give erroneous results when there is a clot or air bubble in the system, the system is not washed regularly, or a small catheter is used (12). On the other hand, in the oscillometric method, the use of inappropriate sized cuff is responsible for incorrect measurements (13). In addition, physical movements of the baby also cause incorrect measurements. In other words, when a difference is detected between the two methods, intraarterially measured blood pressure values may also be incorrect. Kimble et al. determined the ratio of cuff width to arm circumference as 0.45-0.70 for definite results (13). In our study, techniques appropriate to the literature were used in both measurement methods.

There are many studies comparing the oscillometric and intraarterial methods. Lalan et al. and Liu et al. found that the oscillometric method measured higher SBP and lower DBP in sick newborns compared to the intraarterial method, and did not find a significant difference between the two methods in MBP (14,15). Similarly Takci et al. and Meyer et al. revealed that there is a good correlation in MBP between the two methods, but they did not compare the values of SPB and DBP (7,8). In our study, similar to the studies of Lalan et al. and Liu et al. the oscillometric method measured higher SBP, lower DBP compared to the intraarterial method; in contrast, the oscillometric MBP was found to be lower than the intrarterial MBP.

Takci et al. and Diprose et al. stated that the oscillometric method gave high results compared to invasive measurement when MBP was <40 mmHg (7,9). Similar to them, in our study, the oscillometric method measured MBP significantly higher than the intraarterial method at low blood pressure values. In addition, we compared the values of SBP and DBP in our

study, and the oscillometric method tends to measure higher in all three measurements compared to the intraarterial method at low blood pressure values. In our study, low blood pressure values were in the minority, so it may be incorrect to generalize the results.

In our study, the oscillometric method tended to measure DBP and MBP further lower than the intraarterial method in the group whose gestational age is 32 weeks and below. However, similar to the study of Lalan et al.(14), in our study, this difference was not statistically significant for MBP in newborns at ≤32 weeks of gestation.

Finally, Lalan et al. interpretted the parameters such as body weight, postmenstrual age, limbs used (lower/upper limbs), ventilator support, presence of inotropes and low blood pressure (<30 mmHg) that may cause differences between the two methods, and did not identify any variables that affect the measured blood pressures (14). In our study, in addition to Lalan et al, we added use of sedation, nutritional status, arm circumference, surfactant intake, antenatal steroid use, antenatal risk factors such as mothernal smoking status, GDM/DM-hypertension/preeclampsia history of mother, presence of sepsis, erythrocyte support, phototherapy intake, vital signs, and sleep-wake status as independent variables that may affect the difference of two methods. This is one of superiority aspects of our study. As a result of this we found that the use of sedatives in the difference between SBP measurements; surfactant use, gestational week, inotrope use, body weight in the difference between DBP measurements are effective. We have not determined any parameter that affects MBP.

In addition, while Lalan et al. (14) included term and premature newborns in their study, our study is the only study in the literature that includes only premature newborns, in which multiple variables affecting the difference between the two methods were examined. Liu et al. (15) and Lalan et al.(14) included radial and umbilical catheterization together as an invasive method in their studies. In our study we used only umbilical catheterization measurement as an invasive method. This is another superiority aspects of our study.

Umbilical catheterization cannot be performed in daily practice in many NICU in our country due to both cost and patient density. In our study, although a significant difference was found between blood pressures for the two methods, similar to the study of Meyer et al. (8), according to the result of Bland Atman, no systematic difference was found between the two methods. Clinically, there is a harmony between the two methods. For this reason, the oscillometric method can be used instead of the invasive method in centers where the patient density is high.

While interfering the results of our study, it is necessary not to ignore some limitations. Although we evaluated many clinical and demographic variables affecting the correlation between the two methods in our study, many variables related to both instruments and the patients may not have been taken into account. In addition, due to a limited clinical group was examined in this study, it may not be correct to generalize the results to the entire population. Also, in our study, blood pressures were measured and compared once by both methods in order to minimize the intervention in critically premature patients with general condition.

In conclusion, a significant statistical difference was found between the oscillometric method and the intraarterial method. Umbilical catheter-mediated blood pressure measurement should be preferred in newborns with poor general condition and ill. Due to difference between MBP obtained by oscillometric and intraarterial methods was not affected by low gestational week and other independent variables, use of MBP values in the follow-up of premature and sick newborns is more accurate and appropriate. However, MBP is also affected in low blood pressure values. Therefore, the reliability of oscillometric measurement decreases at low blood pressure values.

Ethics Committee Approval: The study was approved by the Ethics Committee of Gazi University on 11.11.2013 with the approval number of 186.

Conflict of Interest: There is no conflict of interest.

Funding: No financial support was received.

Informed Consent: Informed consent was obtained from the families of the participants.

REFERENCES

1. Nuntnarumit P, Yang W, Bada-Ellzey HS. Blood pressure measurements in newborn. Clin Perinatol 1999;26:981-96
2. Fanaroff AA, Fanaroff JM. Blood pressure disorders in the neonate: Hypotension and hypertension. Semin Fetal Neonatal Med. Elsevier Press. 2006;174-181
3. Jones DW, Appel LJ, Sheps SG, Roccella EJ, Lenfant C. Measuring blood pressure accurately: new and persistant challenges. JAMA 2003;289:1027-30
4. Barrington KJ. Umbilical artery catheters in the newborn: effects of catheter materials. Cochrane Database Syst Rev 2000;2:1-12
5. Emery EF, Greenough A. Non-invasive blood pressure monitoring in preterm infants receiving intensive care. Eur J Pediatr 1992;151:136-9.
6. Emery EF, Greenough A. Assessment of non-invasive techniques for measuring blood pressure in preterm infants of birth weight less than or equal to 750 g. Early Hum Dev 1993;33:217-22
7. Takcı S, Yigit S,Korkmaz A, Yurdakök M. Comparison between oscillometric and invasive blood pressure measurements in critically ill premature infants. Acta Paediatr 2012;101:132-135
8. Meyer S, Sander J, Gräber S,Gottschling S,Gortner L. Agreement of invasive versus non-invasive blood pressure in preterm neonates is not dependent on birth weight or gestational age. J Paediatr Child Health 2010;46:249-54
9. Diprose GK, Evans DH, Archer LNJ, Levene MI. Dinamap fails to detect hypotension in very low birthweight infants. ADC 1986;61:771-773
10. Fanaroff AA, Fanaroff JM. Care of the High-Risk Neonate. 6th ed. Philadelphia: Elsevier; 2013
11. Pellicer A, Bravo MC, Madero R, Salas S, Quero J, Cabañas F. Early systemic hypotension and vasopressor support in low birth weight infants: impact on neurodevelopment. Pediatrics 2009;123:1369-76.
12. Weindling AM. Blood pressure monitoring in the newborn. Arch Dis Child 1989;64:444–447.
13. Kimble KJ, Darnall RA Jr, Yelderman M, Ariagno RL, Ream AK. An automated oscillometric technique for estimating mean arterial pressure in critically ill newborns. Anesthesiology 1981;54:423-425
14. Lalan S, Blowey D. Comparison between oscillometric and intra-arterial blood pressure measurements in ill preterm and full-term neonates. Journal of the American Society of Hypertension 2014; 8(1):36–44
15. Liu CW, Chen SJ, Hwang B. Comparison of Blood Pressure in Mature and Premature Neonates Using Direct and İndirect Methods of Measurement. Clinical Neonatology 1998:5(2)