Research Article / Araştırma Makalesi

# The Prediction and Prevention of Spinal Anaesthesia-Induced Hypotension with Perfusion Index and The Effect of Crystalloid

## Perfüzyon İndeks Ölçümü ile Spinal Bloğa Bağlı Gelişen Hipotansiyonun Öngörülmesi-Önlenmesi ve Buna Kristaloid Preloadunun Etkisi

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**Abstract:** Hypotension is a dangerous and common problem for patients under spinal anesthesia. Spinal anesthesia-induced hypotension(SIH) is often arisen from heart rate decrease and venous blood pooling under the spinal block level because of sympathetic blockage. Prediction and prevention of hypotension will be beneficial for the patients' health under spinal blockage. For prediction, many parameters like perfusion index(PI) have been using. This study aims to research the correlation between the patients' hemodynamic parameters, perfusion indices before spinal block and SIH, and the effectiveness of crystalloid preload before spinal block to the usage of ephedrine. Records from 101 patients between 18-100 years age, who underwent surgery with spinal anesthesia were studied. We enroll patients demografical characteristics, ASA-score, sensory-blockage level, opereation period, the patients' position for spinal block, local anethesic form-dosage, blockage level, patients' hemodynamic and PI parameters in the surgery, hypotension time, efedrin first usage time and dosage from records. These results analyzed with t-test, Pearson-Chi-Square, Wilcoxon-signed-rank and Mann-Whitney-U test. SIH were seen in 25,7% of patients. The incidence of hypotension increases with age and block level. Any corelation between SIH and PI degrees before spinal block was not found, but MAP degrees before spinal block were significantly different in hypotension group. 10ml/kg cristaloid-preload was used 37,6% of patients. SIH was not prevented by cristaloid-preload and cristaloid-preload didn't affect efedrine dosage-timing. Cristaloid-preload changed significantly patients heart rate and PI. In this study, we found that PI was not predictive factor for the development of SIH. Besides cristaloid-preload don't avoid development of SIH.
**Keywords:** Perfusion index, cristaloid preload, spinal block induced hypotension

**Özet:** Hipotansiyon, spinal anestezi altındaki hastalar için tehlikeli ve yaygın bir sorundur. Spinal anestezi kaynaklı hipotansiyon (SIH), genellikle sempatik blokaj nedeniyle kalp hızının azalması ve spinal blok seviyesinin altında venöz kan birikmesinden kaynaklanır. Hipotansiyonun tahmini ve önlenmesi, spinal blokaj altındaki hastaların sağlığı için faydalı olacaktır. Hipotansiyon tahmini için perfüzyon indeksi (PI) gibi birçok parametre kullanılmaktadır. Bu çalışmada, spinal blok uygulanan hastalarda blok öncesi perfüzyon indeks ile spinal blok sonrası gelişebilecek hipotansiyon arasındaki ilişki ve spinal blok öncesi iv sıvı verilmesinin spinal blok sonrası gelişebilecek hipotansiyonu önlemede ve operasyon sırasında hipotansiyon tedavisinde kullanılan efedrinin kullanımına olan etkisini değerlendirmek amaçlanmıştır. Spinal anestezi ile opere olan 18-100 yaş arasındaki 101 hastanın kayıtları incelendi. Hastaların demografik özellikleri, ASA skoru, duyusal blokaj seviyesi, operasyon süresi, spinal blok sırasında hastanın pozisyonu, lokal anestezik formu-dozu, blokaj seviyesi, operasyon sırasında hastanın hemodinamik ve PI parametreleri, hipotansiyon süresi, efedrinin ilk kullanım süresi ve dozu kayıtlardan edinildi. Bu sonuçlar t-testi, Pearson-Chi-Square, Wilcoxon-signed-rank ve Mann-Whitney-U testi ile analiz edildi. Hastaların %25,7'sinde SIH görüldü. Hipotansiyon insidansı yaş ve blok seviyesiyle birlikte artmaktadır. Spinal blok öncesi SIH ile PI değerleri arasında korelasyon bulunmadı, ancak spinal blok öncesi MAP değerleri hipotansiyon grubunda anlamlı olarak farklıydı. Hastaların %37,6'sında 10 ml/kg kristaloid preload uygulaması yapılmıştır. Kristaloid preload SIH'i önlemedi ve efedrin doz zamanlamasını etkilemedi. Kristaloid preload hastaların kalp hızını ve PI' sini önemli ölçüde değiştirdi. Bu çalışmada, PI' nin SIH gelişimi için öngörücü bir faktör olmadığını görüldü. Ayrıca kristaloid preloadunun SIH gelişimini engellemediği gözlemlendi.

**Anahtar Kelimeler:** Perfüzyon indeksi, kristaloid preload, spinal blok kaynaklı hipotansiyon

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## 1. Introduction

Two important problems for patients in spinal anaesthesia that occur due to sympathetic blockade are decreased cardiac output and hypotension (1). Spinal anaesthesia-induced hypotension (SIH) degree is determined by peripheral vasomotor tone, baseline volume status and sympathetic activity.

The parameters like perfusion index (PI), pleth variabilty index (PVI), heart rate (HR), heart rate variability (HRV) which is used for prediction of hypotension during spinal anaesthesia (2), help preventing hypotension and treating it rapidly and effecient. Moreover; pharmacological proceses like cristalloid preload, vasopressor usage (3), selection of different local anasthesic drugs and non- pharmacological proceses like selection of patient position during induction of spinal anaesthesia; are used for preventing SIH.

Sympathetic blockage during spinal anasthesia is due to α-1 receptor (arterial vosoconstruction) plus β receptor (increase of heart rate and contractility) blockage. Therefore; vasopressor adrenergic pharmacological drugs is used for treatment of SIH. Efedrine which is one of these drugs, is effective for treating hypotension during spinal and general anaesthesia.

Aim of our retrospective study is to research the prediction of SIH with using perfussion index measured by pulse oximetry which reflects vasomotor tone and calculates from the rate of pulsating arterial flow to non-pulsating blood in the peripheral tissues. Also we research the effect of cristalloid preload on the efedrine usage during spinal anaesthesia.

## 2. Materials And Methods

After approval of the study by xxx Medical Faculty Ethics Committee; we search patients folders ve anaesthesia forms which has elective surgical procedures with spinal anaesthesia at the dates between 05.08.2015 and 05.08.2016 in the Eskişehir Osmangazi Medical Faculty Hospital. We conducted the study in accordance with the principles of the Declaration of Helsinki.

The patients whom took general anaesthesia during spinal blockage for various reasons, were excluded. We recorded patients parturient characteristics (age, gender, weight, height), The American Society of Anesthesiologists physical status classification (ASA) score, sensory blockage level, vital signs, opereation period, the position of patient during spinal induction, local anaesthesic drug which used for spinal anasthesia and its dosage, the amount and first usage time of efedrine (if used), first monitored hypotension time (if there is hypotension) from the patients folders and anaesthesia forms.

In this study the patients HR, PI, systolic arterial pressure (SAP), diastolic arterial pressure (DAB), mean arterial pressure (MAP) and peripheral oxygen saturations ($SpO_2$) values recorded before and after (0.,1., 3., 5., 10., 20., 30., 60. minute) spinal anaethesia from their folders and anaesthesia forms.

Hypotension is defined as non-invasive SAP under 90 mm/Hg, MAP under 60 mm/Hg or a SAP <70% of the baseline SAP. Degree of decrease in SAP ((baseline SAP-least SAP)/ baseline SAP) and degree of decrease in MAP ((baseline MAP-least MAP)/ baseline MAP) are calculated. The patients were mainly separated groups as Group Hypotension Positive (HP) (if there is hypotension) and Group Hypotension Negative (HN) (if there isn't hypotension). We compared all differencies and similarities of the patients parturient characteristics, ASA scores, sensory blockage levels, vital signs, opereation periods, the position of patient during spinal induction, local anaesthesic drug which used for spinal anasthesia and its dosage, the amount and first usage time of efedrine (if used), first monitored hypotension time (if there is hypotension) between Group HP and Group HN.

Also the patients were secondarily classified as Group Preload Positive (PP) (if there is any iv cristalloid preload before spinal anaesthesia) and Group Preload Negative (PN) (if there is no iv cristalloid preload before spinal anaesthesia). Similarly, we

compared all recorded data about the patients between group PP and group PN, just as we compared between group HP and group HN.

### 2.1. Statistical Analysis

All statistical analysis was performed with SPSS ver. 21.0. Data are presented as means ± SDs. Between two independent groups; if dependent variable is normally distributed independent t test is used, if not The Mann-Whitney U test is used. The comprasion between two dependent and one independent variable analysed by Paired-samples t-test if variables are parametric, Wilcoxon signed-rank test if variables are non-parametric. For categorical variables, the chi-square test is used. A p-value less than 0.05 was considered statistically significant. Cut-points are calculated from ROC curves.

### 2.2. Figures, Tables

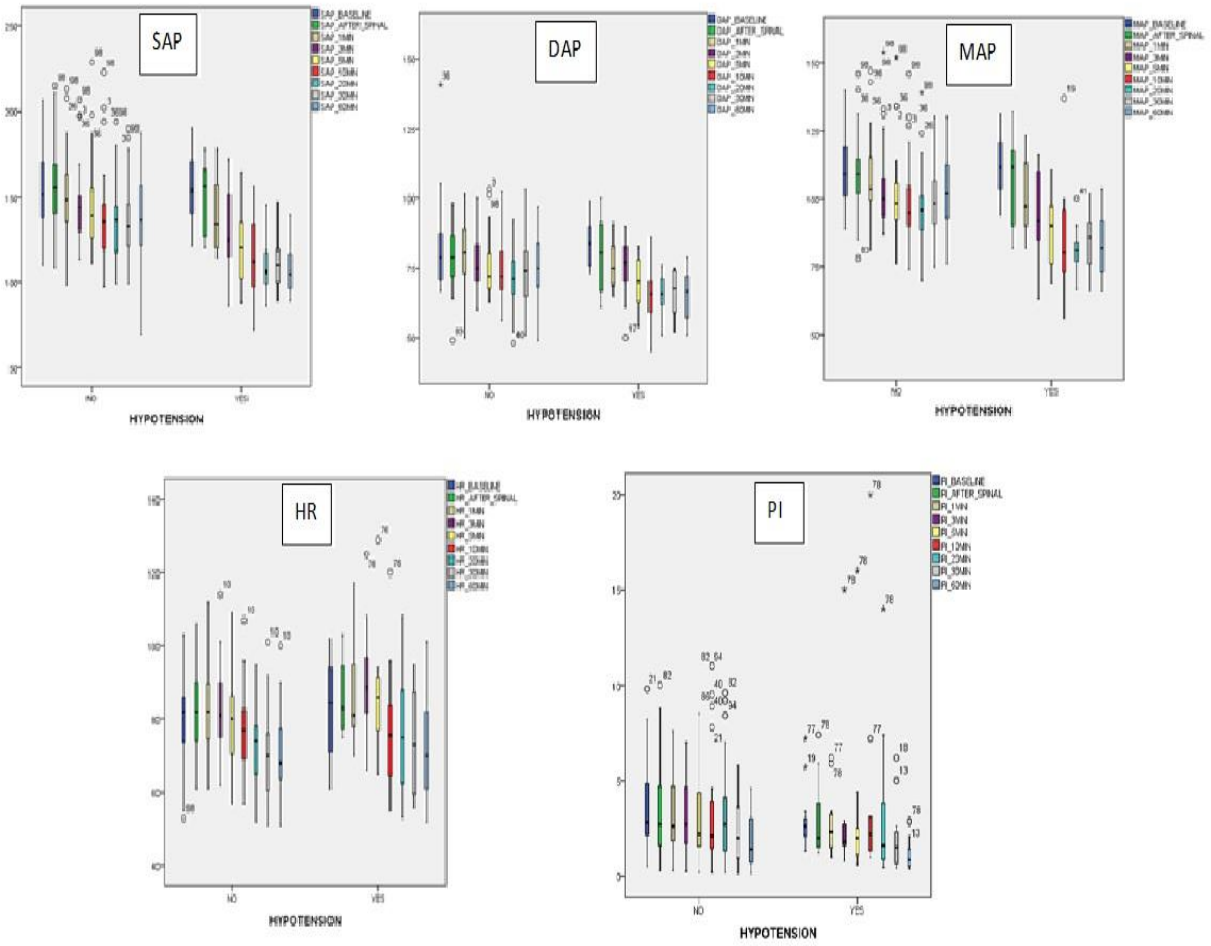


**Figure 1. Hemodynamic parameter changes during surgery**

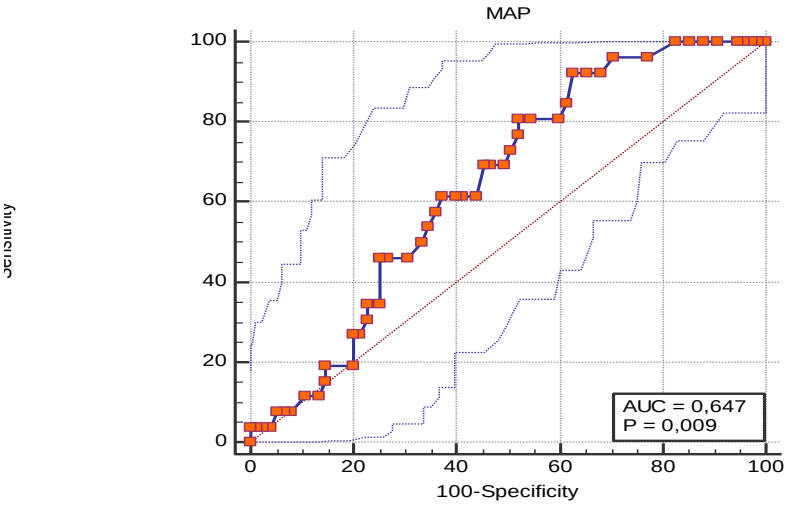


**Figure 2. MAP baseline values – ROC curve**

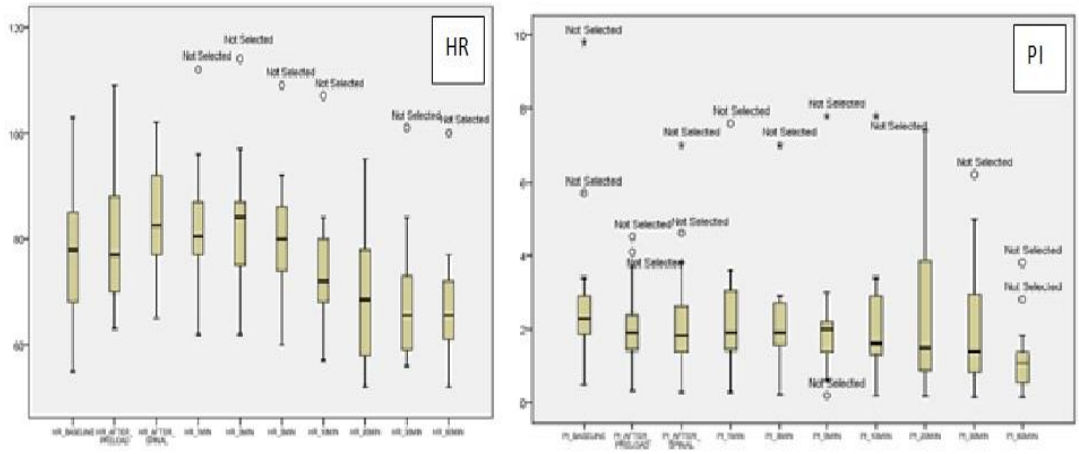


**Figure 3.** HR and PI changes in Group PP

**Table 1.** Patients surgery periods, local anaesthesic drug dosages, first efedrine usage times, first hypotension times, baseline and after preload hemodynamic parameters

| PARAMETERS | Number of patients (n) | Minimum | Maximum | Avarage | Standart derivation |
|---|---|---|---|---|---|
| **Operation Period (min)** | 101 | 8,00 | 120,00 | 50,9901 | 27,18032 |
| **Local Anaesthesic Drug Dosage (ml)** | 101 | 1,60 | 3,00 | 2,0460 | ,19665 |
| **First Efedrine Usage Time (min)** | 14 | 3,00 | 40,00 | 15,2143 | 11,35564 |
| **First Hypotension Times (min)** | 26 | 1,00 | 40,00 | 14,2308 | 10,43190 |
| **SAP Baseline (mmHg)** | 101 | 91,00 | 209,00 | 152,7228 | 24,87694 |
| **SAP After Preload (mmHg)** | 38 | 96,00 | 211,00 | 148,1579 | 28,19002 |

| | | | | | |
|---|---|---|---|---|---|
| **DAP Baseline (mmHg)** | 101 | 54,00 | 141,00 | 81,7200 | 14,03177 |
| **DAP After Preload (mmHg)** | 38 | 48,00 | 115,00 | 79,2368 | 14,79853 |
| **MAP Baseline (mmHg)** | 101 | 69,00 | 149,00 | 109,3762 | 15,86496 |
| **MAP After Preload (mmHg)** | 38 | 71,00 | 150,00 | 107,0000 | 19,07595 |
| **HR Baseline (bpm)** | 101 | 52,00 | 123,00 | 79,7624 | 13,75947 |
| **HR After Preload (bpm)** | 38 | 49,00 | 129,00 | 80,5000 | 16,37194 |
| **PI Baseline** | 101 | ,49 | 11,00 | 3,7703 | 2,43200 |
| **PI After Preload** | 38 | ,33 | 12,00 | 2,6841 | 2,15969 |

**Table 2.**Patients demografic and hemodynamic datas of Group HN and Group HP

| **Characteristics** | **Group HN(n:75 )** | **Group HP(n:26)** | **p** |
|---|---|---|---|
| **Age (year)** | 61,04±15,32 | 67,57±8,69 | **0,009†** |
| **Weight (kg)** | 76,70±13,12 | 78,23±14,35 | 0,839 |
| **Height (cm)** | 170,98±6,89 | 170,07±5,20 | 0,325 |
| **Gender W/M (n)** | 69/6 | 25/1 | 0,472 |
| **Operation period (min)** | 47,53 | 60,96 | 0,12 |
| **ASA (I/II/III)** | 31/30/14 | 8/15/3 | 0,316 |
| **Position (right/left/sitting)** | 12/62/1 | 7/17/2 | 0,087 |
| **Local Anaesthesic Drug Dosage (ml)** | 2,04 | 2,05 | 0,947 |
| **Sensory block level (T6/T7/T8/T10/T11)** | 7/0/33/35/0 | 6/1/11/7/1 | **0,021†** |
| **Efedrine usage yes/no(n)** | 0/75 | 14/12 | **<0,05†** |
| **Preload yes/no(n)** | 28/47 | 10/16 | >0,05 |

**Table 3.**Hemodynamic parameters and perfusion indicis of Group HN and Group HP

| | **Group HN(n:75 )** | **Group HP(n:26 )** | **p** |
|---|---|---|---|
| **SAP baseline (mmHg)** | 150,08±25,55 | 160,34±21,47 | 0,223 |
| **DAP baseline (mmHg)** | 80,72 | 84,53 | 0,095 |
| **MAP baseline (mmHg)** | 107,41 | 115,03 | **0,026†** |
| **$SpO_2$ baseline (mmHg)** | 95,92 | 95,53 | 0,554 |
| **HR baseline (bpm)** | 79,16±14,40 | 81,50±11,79 | 0,369 |
| **PI baseline** | 4,01 | 3,06 | 0,126 |

**Table 4.**Patients demografic and hemodynamic datas of Group PN and Group PP

| Characteristics | Group PP(n:38 ) | Grup PN(n:63) | p |
|---|---|---|---|
| **Age (year)** | 66 | 64 | 0,366 |
| **Weight (kg)** | 75 | 78 | 0,413 |
| **Height (cm)** | 170 | 170 | 0,639 |
| **Gender W/M (n)** | 34/4 | 60/3 | 0,421 |
| **Operation period (min)** | 47,5 | 45 | 0,218 |
| **ASA (I/II/III)** | 12/17/9 | 27/28/8 | 0,295 |
| **Position (right/left/sitting)** | 5/32/1 | 14/47/2 | 0,634 |
| **Local Anaesthesic Drug Dosage (ml)** | 2 | 2 | **0,03** † |
| **Sensory block level (T6/T7/T8/T10/T11)** | 8/1/15/13/1 | 5/0/29/29/0 | 0,072 |
| **Efedrine usage yes/no(n)** | 5/33 | 9/54 | 0,874 |
| **Hypotension yes/no(n)** | 10/28 | 16/47 | 0,918 |
| **Efedrine first usage time (min)** | 5 | 15 | 0,81 |
| **Hypotension first time (min)** | 7,5 | 15 | 0,241 |

**Table 5.** Hemodynamic parameters before and after in Group PP

| Parameters | Group PP (n:75 ) | p |
|---|---|---|
| **SAP baseline (mmHg)**<br>**SAP after preload (mmHg)** | 152,39±24,40<br>148,15±28,19 | 0,14 |
| **DAP baseline (mmHg)**<br>**DAP after preload (mmHg)** | 82,10±14,95<br>79,23±14,79 | 0,224 |
| **MAP baseline (mmHg)**<br>**MAP after preload (mmHg)** | 108,10±14,94<br>107,00±19,07 | 0,319 |
| **HR baseline (bpm)**<br>**HR after preload (bpm)** | 77,81±14,93<br>80,50±16,37 | **0,013**† |
| **PI baseline**<br>**PI after preload** | 3,31±2,48<br>2,59±2,12 | **<0,001**† |

## 3. Results

7 female , 94 male totally 101 patients were included the study whose folders we can get correctly and exactly. Spinal anaesthesia was performed with 25 Gauge (G) Quincke type needle and 0.5% hyperbaric bupivacaine was used for all patients. The mean value of the

patiens age is 62,72±14,17 year, weight is 77,09±13,39 kg, height is 170,75 ±6,48 cm. 92 of the patients surgery was urogenital surgery (91.1%), 2 of them was ortopedical (2%), 6 of them was general surgery (5.9%) and one of them was cardiovascular surgery (1%). The patients were classified with the ASA score I-IV and 39 ASA I (38.6%), 45 ASA II(44.6%), 17 ASA III(16.8%) patient were included in the study. Spinal block was performed in right lateral position to 19 patients (18.8%), in left lateral position to 79 patients(%78.2) and in sitting position to 3 patients (2.97%). The spinal anaesthesia sensory block level which controlled with pinprick test were T6 in 13 patients (12.9%), T7 in 1 patient (0.99%), T8 in 44 patients (43.6%), T10 in 42 patients (43.6%) and T11 in 1 patient (0.99).

The surgery periods, dosage of local anesthetic which used for spinal anaesthesia, first efedrine usage times, first hypotension times, baseline and after preload (if it is used) SAP, DAP, MAP, HR, PI values are presented in Table 1.

Patients (36 patients, 37.6% ) received cristalloid 10 ml/kg before spinal anaesthesia (preload) (Group PP) and rest of the 63 patients (62.4%) didn't receive any preload (Group PN). 26 patients (25.7%) whom hypotension developed during spinal anasthesia is defined as Group HP and efedrine was used 14 of those patients. Group HN is defined as 75 patients whom hypotension didn't devoloped during spinal anaesthesia.

Age (p=0.009) and sensory block level (p=0.021) are significantly different between Group HN and Group HP (Table 2). Increasing age and upper sensory block levels are associated with hypotension. There are no significant differences in baseline SAP, DAP, HR and PI values among the Group HN and Group HP but MAP baseline values are significantly different between the groups (p=0.026) (Table 3; Figure 1). The baseline MAP cut-off point that predicted hypotension as determined by the ROC analyses was 98 with a sensitivity of 92.31% [95% confidence intervals (CI) 74.9-99.1%], a specificity of 37.33% (95% CI 26.4-49.3%) (Figure 2).

Age is not corralated with hypotension first seen time (p=0.180, r=0.380) and efedrin first usage time (p=0.312, r=0.278). Also MAP baseline values aren't corralated with hypotension first seen time (p=0.389, r=0.125) and efedrin first usage time (p=0.256, r=0.378). A significant positive corelation is between age and MAP baseline values (p<0,001, r=0,314). The percent decrease in SAP from baseline is correlated with age (p=0,002, r=0,306), SAP baseline (p<0,001, r=0,437), DAP baseline (p<0,001, r=0,399) and MAP baseline values(p<0,001, r=0,461). Similarly the percent decrease in MAP from baseline is correlated with age (p=0,029, r=0,217), surgery periods (p=0,026, r=0,222), SAP baseline (p<0,001, r=0,343), DAP baseline (p<0,001, r=0,395) and MAP baseline values (p<0,001, r=0,497). PI baseline values are corralated with nor the percent decrease in SAP from baseline neither the percent decrease in MAP from baseline (p=0,796, r=0,026; p=0,886, r=-0,014).

Comprasion of the patients demographic characteristics, surgery and spinal anaesthesia characteristics between Group PP and Group PN are presented in Table 4. Only significant difference is in local anaesthesic drugs dosage which used for spinal blockage (p=0,03). In Group PP; HR and PI is significantly different before and after 10 ml/kg cristalloid preload (p=0,013; p<0,001 ).(Table 5; Figure 3)

## 4. Discussion and Conclusion

Less complication is seen under the central neuroaxial anaesthesia; especially spinal anaesthesia which is the most favorite in surgery, than general anaesthesia. Nevertheless spinal anaesthesia has certain side effects and complications. Most known of these is hypotension (4). Therefore prediction, diagnosis and treatment of hypotension is very important in anaesthesia practice.

Hypotension is important cause of mortality ve morbidity (5) in patients receiving spinal anaesthesia. The ratio of spinal anaesthesia induced hypotension in elderly people is

found 49%-69% (6,7). We found it less than the other studies [25% (26/101)] . This would be because of our patients less age avarage, lower dosage of local anaesthesic drugs for spinal block and no usage of sedation drugs during surgery. (8,9,10).

Additional co-morbid diseases would be incrased and systemic vascular resistance would be decreased in older ages. This would be reason of our hypotension and patient age correlation result (11,12). Carpenter,R.L. et al. have reported that increasing age (≥40 yaş) and upper sensory block levels are risk factors of SIH (4). Also Ullah Khan, M. et al. found that SIH incidence would be risen when sensory block levels had increased like our study (13). The reason for this is reducing compensatory reply to sympathetic blockage when spinal block level. Arterial vasodilatation which is result of sympathetic blockage, will be reduced by compensatory vasoconstruction. At high sympathetic block level, this vasoconstruction reply would be precluded and also sympathetic cardiac neurofibers which go out from $T_{1}$-$_{4}$ vertebra levels, would be blocked. Changing direction and tilt of spinal needles and injection speed of local anaesthesic drugs according to the anaesthetist can alter spinal block level and so hypotension risk.

The patients spinal anaesthesia position is also an effective parameter for devoloping of hypotension. There is no significant differences between positions for devoloping hypotension in our study but rareness of sitting position would be cause to this result. Different studies show different position study results for caesarean section surgeries spinal anaesthesia that hypotension was much more in lateral or sitting position. (14,15) SIH is seen much more in higher ASA scores (16). This could be result of increasing comorbid diseases in higher ASA scores. We didn't find any significant corellation between ASA scores and SIH.

The physiological mechanism of SIH is basicly the blockage of the sympathetic neurofibers and thereupon decreasing of peripheral vascular resistance and venous blood pooling which cause reducing cardiac preload and therefore cardiac output (10). Pre/coload of IV fluids during spinal anaesthesia would be helpful for preventing decrease of cardiac preload and so devoloping hypotension. There isn't certain decision when, how much and which fluids (cristalloid/colloid) must be given (8,17). Buggy,D. et al searched comparison between preanesthetic administration of cristalloids, colloids, and no prehydration for preventing hypotension among spinal anaesthesia in elderly patients and found no differences (6). Dahlgren,G. et al found colloids againist cristalloids, Rout,CC et al found cristalloids beneficial for preventing SIH in the caesarean section surgeries (18,19). It is important that many studies about this subject performed on the caesarean section surgeries. Administration of IV fluids may be more effective in the caesarean section surgeries than the other surgeries because of decrease of cardiac preload due to aortacaval depression of uterus in the pregnants, the necessity of higher sensory block ($T_{4-6}$) for the caesarean section surgeries and result of this the blockage of compensatory vasoconstruction reply. All surgeries of the patients included in the study were non-obstetric surgeries. This could be why we didn't found any efect of cristalloid preload before spinal anaesthesia to SIH.

Efedrine is a vasopressor drug that we use for treatment of hypotension during the anaesthesia. Efedrine usage during spinal anaesthesia used for comprasion of the effectiveness of iv fluid preload or coload in many studies (8). Like Rout,CC et al study, we reported in our study that cristalloid preload had no effect on the efedrine usage among spinal anaesthesia (19).

If hypotension during the spinal anaesthesia can be predicted in which patients would occur, there can be a chance to prevent the patients from hypotension or there can be prepared for the treatment when hypotension devolop. This prediction will help to diminish mortality and morbidity because of hypotension. Perfusion index; which is one of these hemodynamic parameters that used for prediction of hypotension, measure peripheral perfusion and vasomotor tone non-invasively

and continuously from pulse oximetry devoloped by Masimo Signal Extraction Technology (SET®).

Patients peripheral vascular resistance which is critical for progress of SIH to know, can ensure hypotension prediction. For this purpose we observed for the corelation between hypotension and PI values in this study. Although we didn't find any significant corelation, Toyoma,S. et al determined a significant corelation between baseline PI values and hypotension in the caesarean section surgeries under spinal anaesthesia and reported that the cut-off value of PI is 3.5 for SIH (1). Also Yokose,M. et al compared PI, PVI, HRV and HR values for prediction of SIH and only HR is found significant for prediction (2). We found only baseline MAP values was significant for SIH prediction.

Nowadays spinal anaesthesia is used in many surgeries for analgesia and anaesthesia. One of the most physiological side effect of spinal anaesthesia is hypotension. The prediction, diagnosis and treatment of hypotension after spinal anaesthesia can reduce mortality and morbidity of patients under spinal anaesthesia.

PI which is one of the novel hemodynamic parameters used in anaesthesia, can't predict hypotension during spinal anaesthesia in our study. There is a few study, research the corelation PI values and hypotension. More studies must search for the hemodynamic parameters for hypotension prediction.

The cristalloid preload (10ml/kg) before spinal anaesthesia neither prevent from SIH nor decrease efedrine usage. For this reason we don't recommend 10 ml/kg cristalloid preload in the non-obstetrical surgeries. There must be done much more researches for preloads in different surgery types, in different dosages and different iv fluids.

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**Ethics**

**Ethics Committee Approval:** The study was approved by Eskisehir Osmangazi University Noninterventional Clinical Research Ethical Committee (Decision no: 11, Date: 10.10.2016).
**Informed Consent:** This study did not require informed consent.
**Authorship Contributions:** Surgical and Medical Practices: EŞ. Concept: EŞ, SE. Design: EŞ, SE. Data Collection or Processing: EŞ. Analysis or Interpretation: EŞ, SE. Literature Search: EŞ,SE. Writing: EŞ,SE.
**Informed Consent:** The authors declared that it was not considered necessary to get consent from the patients because the study was a prospective observational data analysis.
**Copyright Transfer Form:** Copyright Transfer Form was signed by all authors.
**Conflict of Interest:** No conflict of interest was declared by the authors.
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