Comparison of Hemodynamic Effects of Hyperbaric and Isobaric Bupivacaine in Spinal Anesthesia

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1. INTRODUCTION
Spinal anesthesia is a reversible nerve transmission interruption caused by injection of local anesthetic in subarachnoid space (1). Induction of SA has a very significant effect on many organic systems, including cardiovascular, respiratory, gastrointestinal, renal, endocrine and coagulation system.

Effect of SA on the cardio-circulatory system is primarily indirect and occurs through blockade of sympathetic nervous system and includes a reflex response to the primary cardiovascular effects. Most significant easily measurable effects of SA have changed blood pressure and pulse. The aim of all anesthesiologists is to perform the SA with the least deviation in blood pressure and pulse rate, assuming that the patient was preoperatively with normal BP and pulse. In doing so we are using spinal anesthetics of various baricity. Baricity of anesthetics represents the ratio of the specific density of anesthesia and cerebrospinal fluid at a temperature of 37°C. In practice, the most commonly used hyperbaric (baricity>1.0008) and isobaric anesthetics (baricity 0.998-1.0008). In the liquor space anesthetics act depending on their own baricity: hyperbaric trying as heavier than the fluid to go in the lowest part of liquor space of patient in lying position while isobaric anesthetic is floating in liquor space. To what extent it affects hemodynamic processes is an issue of this paper.

Since the volume and amount of anesthetic, and intervertebral level at which the anesthetic is given, the position in which the patient was located when the application can potentially affect the hemodynamics, the protocol was performed identically in all patients during the study with the same dose and volume of anesthetic and conditions of application of anesthetics.

2. GOAL
Therefore the aim of this work is to present and analyze the differences in the behavior of basic hemodynamic parameters that we measure routinely during each anesthetic (systolic, mean, diastolic blood pressure and pulse), and their differences in relation to values before anesthesia using the same anesthetic (in this case bupivacaine), but with different baricity.

3. PATIENTS AND METHODS
Patients
The results of this study were obtained by prospective clinical study derived from two groups of 30 patients at the Cantonal Hospital Dr Irfan Ljubijankic in Bihac. Patients were indicated for elective surgery in spinal anesthesia.

The group, conditionally called "hyperbaric group" (shorter group H) received hyperbaric 0.5% bupivacaine and in "isobaric group" (shorter group I) isobaric 0.5% bupivacaine.

Patients were subjected to surgery in the field of gynecology, urology, orthopedics, vascular, plastic and rectal surgery. In group H the average age of patients was 55.9 years (± 12.2) and in the age group I was 53.3 years (± 13.83). In the H group was 19 (66.33%) male patients and 11 (36.67%) female and in the group I was 20 (66.66%) males and...

ORIGINAL PAPER SUMMARY
Introduction: Spinal anesthesia presents reversible interruption of nerve transmission within subarachnoid space produced by injection of local anesthetic in cerebrospinal fluid. At the same time it comes to the blockade of particular functions of the nerve transmission. At the focus of this work is the blockade of sympathetic fibres which significantly affect on the behavior of the hemodynamic parameters. Change of these parameters may be very emphasized. One of the possible factors which may implicate is baricity of spinal anesthetic. The goals of the work are to determine how does the baricity affect the behavior of the basic hemodynamic parameters and also the height and distribution of the sensory block. Methods: The research has been made on two groups who were given the same amount of 0.5% bupivacaine of different baricity; to the first group hyperbaric with 8,25% glucose and to the second an isobaric without any additives. At that time the application has been made on the same vertebral level, in same position. The research has been made on the patients in Hospital „Dr Irfan Ljubijankic“ in Bihac. Results: In hyperbaric group, systolic, mean, diastolic blood pressure and pulse frequency decreased 19,41%, 18,75%, 17,54% and 10,26% respectively, significantly greater than in isobaric group (7,23%, 2,65%, 1,62% and 9,38%). Gained results with high statistic signficancy show that the baricity have an essential effect on the behavior of the basic hemodynamic parameters in the sense of reduction of the arterial blood pressure and slowing down of the pulse. At the same time isobaric anesthetic give smaller deviation of the parameters. Conclusion: By choosing the anesthetics of the appropriate baricity we can significantly affect hemodynamic status of the patient.

Keywords: hemodynamic effects, bupivacaine, spinal anesthesia
patients in the hyperbaric group was given hyperbaric bupivacaine with baricity of 1.020 where baricity is made by factory incorporation of glucose in solution in an anesthetic concentration of 8.25%. The second group received isobaric bupivacaine with baricity of 0.999 which is considered clinically isobaric anesthetic. Application of anesthesia is performed in all patients in the same way: after lumbar puncture and verification of free fluid leak in all four quadrants with spinal needle 25G called Quincke-type with the tip of the needle directed caudally. Puncture is made at the same level and same position with the application in space between vertebrae L3-L4 in a sitting position.

Monitoring of the patient

Instrumental monitoring is done using the monitor Datex® following these parameters:
- Non invasive measurement systolic, mean and diastolic arterial blood pressure at intervals of three minutes.
- Heart rate
- ECG
- Pulseoximetry
- Ethical aspects

All patients given written informed consent for surgery, anesthesia and all the tests during treatment. All proceedings in which the patients were subjected are routine and performed in order to achieve better therapeutic approaches to the patient.

Statistical analysis

At the end of testing the data obtained were subjected to statistical processing. Applied is a statistical test t test for paired samples. In addition are established quantitative measures of behavior of observed hemodynamic parameters, comparing values before anesthesia and average values during anesthesia for the group observed.

4. RESULTS

In table No. 1 are established quantitative measures of changes in the values of the observed basic hemodynamic parameters before and during anesthesia, as well as indicators of relative changes in these values in both groups.

From the data of the Table 1 is evident that in the observed groups came to changes in blood pressure and pulse rate in terms of reducing blood pressure and pulse rate deceleration. It is evident that, on the basis of relative indicators in hyperbaric group the change of these parameters was emphasized in relation to isobaric group. In Table 2 are summarized the descriptive values measured in a group where is applied hyperbaric spinal anesthesia.

In Table 3 are shown most important descriptive measure of the hyperbaric group and tested for statistical significance with t test. Based on the calculated values can be concluded that there is a statistically highly significant difference (p<0.01) of before anesthesia values of systolic, mean, diastolic blood pressure and pulse rate and their average values during anesthesia. The observed pattern, as it is evident from Table 1 average value of systolic pressure during anesthesia is lower than values before anesthesia for 19.41%, the average value of the mean blood pressure during anesthesia is lower than before anesthesia for 19.16%, the average value of diastolic pressure during anesthesia is lower than before anesthesia for 18.75%. In the observed sample average diastolic blood pressure during anesthesia is lower than before anesthesia for 17.54%, while the average pulse rate during anesthesia is lower than before anesthesia to 10.26%.

Table 4 gives descriptive measures in a group of patients, which received isobaric spinal anesthesia.

In Table 5 are shown descriptive measures of isobaric groups and tested for statistical significance with t test. Based on the calculated values it can be concluded that there is a statistically highly significant difference (p<0.01) between value before anesthesia of the systolic, mean blood pressure and pulse rate and their average values during anesthesia. We should note that changes in diastolic pressure was not significantly changed in isobaric group.
If we go back to the quantitative values from the table 1, the average value of systolic blood pressure in isobaric group during anesthesia is lower than before anesthesia to 7.22%, mean arterial pressure to 2.65%, diastolic pressure to 13.83% and pulse rate to 9.38%.

By applying the t test, changes in parameters of both groups that are compared to preoperative values are statistically highly significant (p<0.01). The exception is the value of diastolic pressure in isobaric group, which was negligible compared to the preoperative value (only 1.62%) and this change is not at all statistically significant (p>0.05).

Based on the calculated value of t test for paired samples, and quantitative values of decrease in hemodynamic parameters during anesthesia compared to values before anesthesia, it can be concluded that the procedure with isobaric spinal anesthetics, the anesthesia is achieved with minor deviations in hemodynamic parameters compared to hyperbaric spinal anesthesia. Doing so should not be forgotten that isobaric anesthesia due to the distribution block cannot fully substitute hyperbaric anesthesia.

5. DISCUSSION

Results obtained in the study showed significant changes in terms of reduction of basic hemodynamic variables during anesthesia compared with values before anesthesia in terms of lowering blood pressure and pulse rate deceleration. There is also a significant difference in emphasis in terms of application of different anesthetic baricity. Changes in hyperbaric group were significantly higher than in isobaric with all measured parameters deviate significantly more than in hyperbaric than in isobaric group.

Spontaneous changes during anesthesia were very pronounced anesthetic and various other physiological effects (the best example—anesthesia for the caesarian section). Due to the minimal amount of anesthetic and negligible absorption of fluid in the blood, concentration in blood is far below those concentrations of anesthetics required to produce a direct effect on myocardium and smooth muscles within the walls of blood vessels. Since the direct effect of anesthetics on the circulatory system can be excluded, it is evident that these changes occur indirectly, through the sympathetic part of vegetative nervous system. In addition to sensory and motor block anesthesia produces vegetative block or sympathocolisis.

Sympathocolisis causes dilatation of the arteries and reducing peripheral resistance, for a maximum of 15-18% because smooth muscle in arterioles retains a significant level of tone after pharmacologically caused sympathetic denervation (4). It also causes dilatation of the veins, with veins and veins becoming a considerably weaker layer of smooth muscle in their wall does not retain a significant residual tone after acute sympathetic denervation, but in fact they become maximally dilated. Vasodilatation on one side depends on intraluminal hydrostatic pressure and on the other side depends on gravity. If the veins without sympathetic tone lie below the level of the right atrium, gravity causes blood to collect in this collection dilated blood vessels. If veins without nervous support veins lie above the level of the right atrium, gravity causes the return of blood to the heart. Venous return (preload) therefore depends on the position of the patient during spinal anesthesia, especially during high spinal block (5).

From the obtained results it could be concluded that sympathocolisis was less pronounced when applying isobaric anesthetic where baricity contributed to less extensive spread of anesthetic and indirect small reduction in blood pressure compared with the hyperbaric group. However, only connecting blocks with a height level of anesthesia would be excessive simplification, because the relationship is not linear—therefore not easily predictable or precise (6).

Partial blockage results in a reflex increase in activity of the unaffected part of sympathetic system so vasoconstriction occurs in parts of the body innervated with intact part. Mutual reaction between two phenomena resulting in values that we received in the survey.

The behavior of hemodynamic parameters may be affected by other factors such as the position of the patient during anesthesia, possible dehydration and vasoactive drugs (e.g. antihypertensives). This survey strictly on account was taken the patients who could identify such “confounding factor” is not even included in the study.

In the literature, the results of similar studies are contradictory, and this was the impetus for the development of this research. Famous American author E. Abouleish argue that the appli-

### Table 3. Testing of statistical significance between t test for paired samples in hyperbaric group. p < 0.01 = highly significant statistical difference. p > 0.05 = without significant statistical difference

<table>
<thead>
<tr>
<th>No.</th>
<th>Pair</th>
<th>Parameter</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Value before anesthesia</td>
<td>Systolic BP (P.S. 2)</td>
<td>11.834</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>Mean BP before anesthesia</td>
<td>Mean BP (P.A. 2)</td>
<td>80.80</td>
<td>15.02</td>
</tr>
<tr>
<td>3</td>
<td>Diastolic BP before anesthesia</td>
<td>Systolic BP (O.D. 2)</td>
<td>77.10</td>
<td>7.74</td>
</tr>
<tr>
<td>4</td>
<td>Heart rate before anesthesia</td>
<td>Mean BP (O.D. 2)</td>
<td>73.22</td>
<td>13.57</td>
</tr>
<tr>
<td>5</td>
<td>Minimum value during anesthesia</td>
<td>Mean BP (O.P. 2)</td>
<td>120.53</td>
<td>13.93</td>
</tr>
<tr>
<td>6</td>
<td>Maximum value during anesthesia</td>
<td>Mean BP (O.P. 1)</td>
<td>87.73</td>
<td>9.04</td>
</tr>
<tr>
<td>7</td>
<td>Mean value during anesthesia</td>
<td>Mean BP (O.D. 2)</td>
<td>66.47</td>
<td>15.52</td>
</tr>
<tr>
<td>8</td>
<td>Systolic BP</td>
<td>Systolic BP (O_S. 2)</td>
<td>15.064</td>
<td>0.000</td>
</tr>
<tr>
<td>9</td>
<td>Mean BP</td>
<td>Mean BP (O_A. 2)</td>
<td>10.908</td>
<td>0.000</td>
</tr>
</tbody>
</table>

### Table 4. Isobaric Group – Basic Descriptive Measures

<table>
<thead>
<tr>
<th>No.</th>
<th>Pair</th>
<th>Parameter</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Value before anesthesia</td>
<td>Systolic BP (P. S. 2)</td>
<td>95.40</td>
<td>9.29</td>
</tr>
<tr>
<td>2</td>
<td>Mean BP before anesthesia</td>
<td>Mean BP (P.A. 2)</td>
<td>78.37</td>
<td>8.93</td>
</tr>
<tr>
<td>3</td>
<td>Diastolic BP before anesthesia</td>
<td>Diastolic BP (P.D. 2)</td>
<td>92.87</td>
<td>8.26</td>
</tr>
<tr>
<td>4</td>
<td>Heart rate before anesthesia</td>
<td>Heart rate (O.P. 2)</td>
<td>7.22</td>
<td>13.57</td>
</tr>
<tr>
<td>5</td>
<td>Minimum value during anesthesia</td>
<td>Mean BP (O.P. 2)</td>
<td>2.65</td>
<td>8.26</td>
</tr>
<tr>
<td>6</td>
<td>Maximum value during anesthesia</td>
<td>Heart rate (O.P. 2)</td>
<td>5.772</td>
<td>0.000</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>No.</th>
<th>Pair</th>
<th>t test value</th>
<th>Significance level</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Systolic BP before anesthesia/Average systolic BP during anesthesia (P_S_2):(O_S_2)</td>
<td>3.902</td>
<td>0.001</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>2.</td>
<td>Mean BP before anesthesia/ Average mean BP during anesthesia (P_A_2):(O_A_2)</td>
<td>3.732</td>
<td>0.001</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>3.</td>
<td>Diastolic BP before anesthesia/Average diastolic BP during anesthesia (P_D_2):(O_D_2)</td>
<td>1.856</td>
<td>0.074</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>4.</td>
<td>Hearth rate before anesthesia/ Average hearth rate during anesthesia (P_P_2):(O_P_2)</td>
<td>5.811</td>
<td>0.000</td>
<td>p &lt; 0.01</td>
</tr>
</tbody>
</table>

Table 5. Testing Of Statistical Significance Between T Test For Paired Samples In Isobaric Group. p < 0.01 = highly significant statistical difference. p < 0.05 = significant statistical difference. p > 0.05 = without significant statistical difference.

Reduction of venous flow.

Sympathetic accelerators originate from sympathetic fibers of segments T1-T4, and when the transmission is interrupted activity of spinal anesthesia remains functionally intact nervous vagus no counter and it certainly is one of the causes of bradycardia. Several reflex mechanisms that respond to reduced venous flow may also play a role in the appearance of bradycardia in spinal anesthesia. Cardiac pacemaker slowing down their activity with reduced myocardial fiber stretching. Mechanoceptors located in the heart of hollow veins show greater activity during the period of reduced flow of venous blood, and come to the vagus-mediated bradycardia. This is considered a protective response in the event of a critical reduction of venous blood flow to the heart (11).

In persons with intact sympathetic function, reduced preload and resulting hypotension should lead to stimulation baroreceptors located in the heart and aorta, which would have the effect of accelerating pulse. However, adherent arm of the baroreceptor sympathetic reflex goes through and therefore, depending on the amount of blocks may not be functional (11, 12). Green believes that in a situation where both already mentioned reflexes are preserved, that in the spinal anesthesia, venous low-pressure receptors of the dominant high-pressure arterial baroreceptors lead to the reduction of the flow and the primary reaction is bradycardia (13). This is consistent with findings in the survey that there is relatively little difference in the changes in pulse between hyperbaric and isobaric group.

For the correction of bradycardia most often used is atropine. It is particularly useful when bradycardia is associated with hypotension, to place a patient in position with legs elevated and add vazoepresor with beta-agonist action, such as ephedrine.

6. CONCLUSION

In conclusion we can say that baricity is a significant factor that indirectly affects the behavior of blood pressure and pulse, and that changes in blood pressure and pulse slowing are more pronounced in patients who received hyperbaric anesthetic formulation compared with the same formulation of isobaric anesthetic.

REFERENCES


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