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CARDIOVASCULAR CHANGES IN HUMAN BODY AFTER CHANGING POSITION SUPINE TO PRONE

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A significant amount of surgeries and medical manipulations are performed in prone position. This position is supposed to be one of the most complicated for anesthesiologist because of difficulties with airway management, possibility of nerve and soft tissue compression, high risk of postoperative visual loss. Prone position is known to be accompanied by several physiologic changes, but they are not described comprehensively in modern literature.

Hemodynamic changes after turning a person into prone position are usually described as the decreasing of cardiac output [6,7,12]. Several studies did not reveal any cardio-vascular changes in prone position [4,15]. These differences could be explained by a significant heterogeneity of types of the examined prone position, methods and time of examination. Some of them were performed on non-anesthetized volunteers, but another on patients under different types of anesthesia. Significant influence on the results of such investigations can perform basic cardiac function, fasting period and volume preload [8,12].

The most precise methods of hemodynamic monitoring are invasive thus potentially dangerous. That is why the majority of studies were performed on patients under anesthesia. Anesthesia itself has a significant influence on hemodynamic pattern so these data cannot be routinely extrapolated on patients without anesthesia. For hemodynamic examination of non-anesthetized people non-invasive bioimpedance method is one of the most suitable. Some papers have shown its accuracy. Except of critical hemodynamic disturbances [3], this method is reliable for clinical practice. Waldron N. et al. compared bioelectance and transesophageal echocardiography for hemodynamic monitoring of patients during colorectal surgery and found no difference [1]. The same data obtained Matsuda Y. et al. [11] during surgical treatment of pheochromocytoma.

Aim of the study was to examine cardio-vascular changes in non-anesthetized humans after turning them into prone position and the relationship of these changes with age and body mass index.

**Material and methods.** After approval of local ethics committee, we performed an observational prospective study without control group of 200 patients 18-75 y.o. The study was performed in SI “Sytenko Institute of Spine and Joint Pathology of National Academy of Medical Science of Ukraine” in 2016-2018 years. Examined patients were elected to 1-2 segment lumbar spine surgery. Mean age was 46.9±14.3 y.o., mean body mass index (BMI) was 27.6±4.8 kg/m². There were 118 male and 82 female patients. Exclusion criteria were NYHA > 1 (New York Heart Association Functional Classification), ASA > 2 (American Society of Anesthesiologists Classification), low back pain >4 VNS (Visual Numeric Scale). The patients were examined the day before surgery at the same time (3 p.m.) using thoracic electrical bioimpedance (TEB) method by G. Kubićek (ReoComProfessional, Ukraine) and standard non-invasive measurement of blood pressure using patient monitor Utas UM-300. We monitored hemodynamic parameters 3 times: in supine position (SP), 5 min after turning into prone position (PP5) and 20 min after turning into prone position (PP20). We also calculated the duration of cardiac cycle phases. One investigator performed all measurements. Data were analyzed for normal distribution using Colmogorov-Smirnov analysis and continuous variables were expressed as the Mean ± σ. Student T-test was used to compare groups of parameters. We used analysis of variance (ANOVA) for examination of influence of anthropometric parameters on hemodynamic changes (IBM SPSS 9.0).

**Results and discussion.** The results of our investigation are shown in Table 1.

<table>
<thead>
<tr>
<th>Hemodynamic parameter</th>
<th>Supine position</th>
<th>Prone position 5 min</th>
<th>Prone position 20 min</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP, mm Hg</td>
<td>126.8±1.9</td>
<td>127.5±1.7</td>
<td>127.3±1.8</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>DBP, mm Hg</td>
<td>79.8±1.8</td>
<td>83.4±1.8</td>
<td>85.9±1.1</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>SV, ml</td>
<td>64.8±2.6</td>
<td>53.5±2.2</td>
<td>55.0±2.3</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>SVI, l/m²</td>
<td>37.0±1.5</td>
<td>31.8±1.3</td>
<td>32.5±1.3</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>CO, l/min</td>
<td>4.7±0.2</td>
<td>4.3±0.3</td>
<td>4.1±0.5</td>
<td>&gt;0.05</td>
<td>&lt;0.001</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>SVRI, din·sec·m²/cm³</td>
<td>2930.9±119.6</td>
<td>3935.2±198.5</td>
<td>3678.4±156.3</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HR, beats/min</td>
<td>73.9±2.4</td>
<td>78.1±2.8</td>
<td>77.0±1.9</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Asynchronous contraction, sec</td>
<td>0.084±0.00274</td>
<td>0.0969±0.00246</td>
<td>0.0965±0.00258</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Isovolumetric contraction, sec</td>
<td>0.0298±0.00017</td>
<td>0.0299±0.00012</td>
<td>0.0298±0.00014</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Rapid ejection, sec</td>
<td>0.0529±0.0056</td>
<td>0.0369±0.0039</td>
<td>0.0452±0.00529</td>
<td>&lt;0.01</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Reduced ejection, sec</td>
<td>0.2268±0.0040</td>
<td>0.2104±0.0043</td>
<td>0.2191±0.0045</td>
<td>&lt;0.001</td>
<td>&lt;0.05</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Total ejection period, sec</td>
<td>0.2714±0.0043</td>
<td>0.2450±0.0048</td>
<td>0.2551±0.0049</td>
<td>&lt;0.001</td>
<td>&lt;0.005</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Notes: P1 – Supine Position vs Prone Position 5 min, P2 – Supine Position vs Prone Position 20 min, P3 – Prone Position 5 min vs Prone Position 20 min.
We found that systolic blood pressure (SBP) did not change after turning patients into prone position in any period of investigation. Diastolic blood pressure (DBP) increased significantly after turning (PP5) and stayed increased during the time of investigation (PP20). Stroke volume (SV) and stroke volume index (SVI) decreased 5 min after turning into prone position (PP5) by 18% and stayed decreased during the time of investigation. Systemic vascular resistance index (SVRI) increased by 34% after changing of position and then slightly decreased after 20 min.

We have also found significant changes in cardiac cycle. The duration of asynchronous contraction phase increased by 35% and the duration of all ejection phases decreased after changing the position from supine to prone. Rapid ejection reduced by 30%, reduced ejection – by 7%, total ejection by 10%.

We also performed analysis of variance to evaluate the influence of age, sex and BMI on the changes of hemodynamic parameters. We found the influence of age >60 y.o. on increasing of SVRI (p=0.006) and influence of age > 60 y.o. and BMI >25 on decreasing of SVI (p=0.01 and p=0.04 respectively). There was no influence of sex on any variables.

This study was aimed to find the mechanism of physiologic changes in cardio-vascular system after turning the patient into prone position. These changes are usually described as the result of increased intraabdominal pressure that puts direct pressure to inferior vena cava and decreased venous return. Increased thoracic pressure causes decreased left ventricular compliance and filling, resulting in reductions of ventricular volume, stroke volume and cardiac index, while raising central venous pressure [8].

Hemodynamic changes in healthy volunteers after turning to prone position were analyzed by Wadsworth R. et al [16]. They found the decreasing of cardiac index by 20% in knee-chest position and 17% on Retton-Hall frame. We examined patients in plane prone position and we also revealed decreasing of SVI by 18%.

In the recent study [5] Shimizu M. et al. conducted the evaluation of cardiovascular function in supine and prone position in non-anesthetized patients using quantitative gated single-photon emission computed tomography. They revealed the decreasing of SVI by 14% in patients without significant cardiovascular problems. The negative effects of prone positioning were more significant in the patients with poor cardiac function. The authors did not measure blood pressure in the examined patients so they could not make conclusions as to the changes of systemic vascular resistance that play significant role according to our data.

Measurements of blood pressure in different positions (sitting, supine and prone) was performed by Tabara Y. et al. [10]. They found a significant drop of systolic BP and raising of heart rate after turning from supine to prone position. The principal difference of their investigation from our data was the fact that they measured BP 1 minute after changing the position. Our data shows already compensated hemodynamics 5 and 20 minutes after turning. Interestingly, the same result obtained researchers from Iran [14], but they measured BP 15 minutes after turning patients into prone position. In both articles authors described a drop of systolic BP by only 5 mm Hg and no difference of diastolic BP.

Backofen J. et al. examined patients with cardio-vascular problems under general anesthesia. They found that turning of patients into prone position leads to decreasing of SV up to 24%. Mean arterial pressure maintained due to increasing of SVR. Pump B. et al. [9] showed that changing of position leads to sympathetic activation with increasing of heart rate, SVR and norepinephrine level. Similar changes we found in patients without serious cardio-vascular abnormalities.

The only one article we could find according to cardiac cycle changes between supine and prone positions [13]. Authors found only decreasing of cycle length and increasing of pulse transmission time. All another parameters of cardiac cycle did not change significantly, but the investigation was performed only on 8 men aged 24-32 years. Our data require further investigations to explain the obtained postural changes in cardiac cycle.

Thus, we found that after turning people from supine to prone position the most significant changes occur with SVRI, as universal reaction of the circulatory system to changes of environment. Healthy myocardium is able to overwhelm the increased systemic vascular resistance. We found the decreasing of SVI after turning to prone position in whole population. Elderly people and people with increased BMI have limited cardiovascular reserve that probably leads to a more significant reducing of stroke volume index after turning them into prone position. This fact should be recognized when planning anesthesia for surgery in prone position.

Conclusion. We found that in healthy non-anesthetized people turning from supine to prone position leads to significant cardiovascular changes. Stroke volume and stroke volume index decreased by 18%, systemic vascular resistance index increased by 34% and diastolic blood pressure increased by 7%. Changes of SVRI were influenced by age and changes of SVI were influenced by age and BMI.

We also found that positioning prone have been accompanied by changes of cardiac cycle. We revealed shortening of both ejection periods and prolonging of asynchronous contraction period.

According to the obtained results, we suppose that under anesthesia these postural changes could be additionally influenced by vasodilation effect of anesthetics that is extremely dangerous in elderly and obese patients.

REFERENCES


Синдром раздраженного кишечника (СРК) – распространенное функциональное кишечное расстройство, часто его варьирует в пределах от 5% до 20% случаев в популяции в зависимости от географического региона и критериев, применяемых для диагностики [11,16]. Определяющими признаками СРК является боль в животе в ассоциации с изменением кишечной функции, проявляющимся преобладанием диареи (СРК-Д), либо запоров (СРК-З) или чередованием (СРК-С-смешанный вариант). Другие ассоциированные симптомы включают вздутие живота, чувство неполного опорожнения кишечника. Спектр абдоминальной боли варьирует от незначительной до нарушающей жизнедеятельности пациента. Несмотря на значительное распространение СРК по всему миру, диагностика и ведение пациентов с СРК остаются вызовом для систем здравоохранения всех стран. Выбор соответствующей терапии для пациентов с СРК осложняется гетерогенностью патофизиологических механизмов его развития и разнообразием популяции пациентов, также, как и широким спектром неспецифических симптомов, которые могут испытывать пациенты. Один из главных авторов внедрения в клиническую практику диагноза СРК профессор Douglas A. Drossman в 1998 г. однозначно высказался, что СРК – био-психосоциальное заболевание, в 2006 г. он же писал: «В последние годы гистологические исследования показали, что различия между функциональными и органическими изменениями стали размытыми», а в 2013 году: «СРК – совокупность симптомов с гетерогенными определяющими факторами» [цит. по 1,5,8]. Диагноз СРК требует вдумчивого подхода, ограниченных диагностических тестов и тщательного наблюдения. Для большинства пациентов, когда присутствуют диагностические критерии СРК и отсутствуют симптомы тревоги и депрессии, необходимость выполнения диагностических тестов должна быть минимальной [9].