Sleep Quality after Coronary Artery Bypass Graft Surgery: Comparing Pulsatile and Nonpulsatile Pump Flow

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Abstract: Poor postoperative sleep quality is a common problem in patients undergoing coronary artery bypass graft surgery (CABG). The purpose of this study was to compare the effect of pulsatile and nonpulsatile pump flow on sleep quality of these patients. In this clinical trial, 52 patients undergoing on pump CABG surgery with the roller pump were randomly divided into two equal groups of 26 patients: group 1 using pulsatile pump flow and group 2 nonpulsatile pump flow while the heart was arrested. Sleep score of both groups was evaluated by Pittsburgh Sleep Quality Index questionnaire 2 days before operation and 1 month after operation, and they were compared with each other. Analysis was performed with SPSS software version 22 (SPSS for Windows Inc., Chicago, IL) using the independent t-test, chi-square test, and Fisher exact test. Both groups were the same in demographic characteristics and risk factors such as age, gender, diabetes mellitus, hypertension, hyperlipidemia, smoking, body mass index, and preoperative ejection fraction. Operation data showed no difference between two groups considering cardiopulmonary bypass time and cardiac arrest time. Preoperative sleep quality score of both groups had no significant difference (p = .84). One month postoperative sleep quality score of the pulsatile group was significantly better than that of the nonpulsatile group (p = .04). Using pulsatile flow cardiopulmonary bypass can effectively decrease postoperative sleep disorders in comparison to nonpulsatile flow. Keywords: coronary artery bypass, pulsatile flow, cardiopulmonary bypass, sleep initiation and maintenance disorders, cardiac surgical procedures.

Despite the global improvement in living standards, many people are now suffering from coronary artery disease. Coronary artery bypass graft surgery (CABG) is an effective way to relieve chest pain, reduce mortality and morbidities of coronary artery disease, and improve quality of life (1–3). Besides the important therapeutic role of CABG, it is associated with some postoperative morbidities including sleep disturbance (1–3). Sleep disturbance is associated with poor quality of life (1–3) and poor recovery after operation (4). Some of the reasons of post-cardiac surgery insomnia are physical factors (pain, dyspnea, and nocturia), environmental factors (noise and light), psychological factors (anxiety and depression), and personal factors (age and gender) (3). It is shown that off pump CABG may be associated with less postoperative sleep disturbance, suggesting the role of cardiopulmonary bypass (CPB) on sleep (5,6). In some studies, it is shown that loss of physiological pulsatile flow following CPB is one of the reasons of vital organ failure and prolongation of recovery time after cardiac surgery (7). Although better organ protection is controversial between pulsatile and nonpulsatile CPB (8), there is growing evidence that pulsatile flow therapy could be considered as one of the therapeutic strategies aimed at reducing the risk of critical organ
damage after prolonged CPB in high-risk cardiac patients (11). This study has tried to evaluate the effect of pulsatile pump flow on post-CABG insomnia and compare its effect with the conventional nonpulsatile flow.

MATERIALS AND METHODS

This study is a double blind randomized clinical trial (IRCT20190807044469N1) performed on patients undergoing CABG by a single surgeon in Chamran Heart Center, Isfahan, Iran. The inclusion criteria were all patients undergoing CABG surgery, patient consent to participate in the study, body mass index (BMI) <35, age <70 years, no history of stroke or transient ischemic attack (TIA), no preoperative sleep disturbance, no chronic alcohol consumption, no addiction, no usage of anti-anxiety or antidepressant drugs, and the ability to respond correctly to the questionnaire. The exclusion criteria were postoperative patient inaccessibility, postoperative stroke, diuretic medications, postoperative heart failure causing dyspnea at night, postoperative intensive care unit (ICU) stay longer than 5 days, CPB duration greater than 142 minutes, aortic clamp duration greater than 88 minutes (12), and unpredictable events that interfere with the usual surgical procedure such as cardiac arrest and intra-aortic balloon pump. Estimated sample size was 20 patients in each group considering 95% confidence level, 80% test power, and 20% loss of samples during the test (13). The data collection tool was the Pittsburgh Sleep Quality questionnaire, designed by Buysse and colleagues in 1989, with a sensitivity of 89.6% and a specificity of 86.5% (14). Persian version of the questionnaire is prepared by Farrahi and colleagues in 2008 showing Cronbach’s alpha coefficient .89, sensitivity 100%, and specificity of 93% (15). The questionnaire consists of seven subscales assessing subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Questions are scored on a four-point Likert scale from 0 to 3. The overall score is from 0 to 21. A higher score indicates poorer sleep quality, and a score of less than 5 indicates good sleep quality.

After obtaining permission from the Medical Ethics Committee of the university (IR.MUI.MED.REC.1398.235), 52 patients were selected from the target population and randomly (simple non-probability) divided in two groups of pulsatile and nonpulsatile. The written consent form was completed by the participants, and the Pittsburgh Sleep Quality questionnaire was filled 2 days before surgery. Surgery was performed by a single surgeon using the same operative techniques and anesthetic drugs.

A Stockert S5 heart–lung machine was used as the roller pump for all patients, and the setting was adjusted as follows for the pulsatile group: base flow: 30%, pulse width: 40%, and frequency: 70 bpm. Pulsatile flow was used only during the cardiac arrest time (asynchronous). Mean arterial blood pressure was maintained between 80 and 90 mmHg throughout the pump time; noradrenaline infusion was used as the drug of choice when full pump flow did not make the target blood pressure. The Pittsburgh second questionnaire was filled 1 month later. Sleep quality score was compared between the two groups and either of the groups separately. Analysis was carried out with SPSS software version 22 using the independent t-test, chi-square test, and Fisher exact test.

RESULTS

Sixty-nine patients underwent preoperative evaluation, 52 patients were included in the study, and 47 patients completed the study (Figure 1). The patients’ mean age was 56.4 (47–68) years in the pulsatile group and 58.7 (42–68) years in the nonpulsatile group. Patients in both groups were similar in terms of gender, diabetes, hypertension, hyperlipidemia, cigarette smoking, BMI, and preoperative ejection fraction (EF) (Tables 1 and 2). Operative and postoperative data showed that there was no significant difference between the two groups in terms of CPB duration, aortic cross clamp time, ICU stay, and hospital stay (Table 2).

Preoperative sleep quality of pulsatile and nonpulsatile groups was 3.7 ± 1.2 and 3.6 ± 1.1, respectively, which had no statistically significant difference (p = .84). Both groups had increased scores 1 month after surgery (Table 3), but the nonpulsatile group had a significantly higher score than the pulsatile group (p = .04), showing a significant score change difference between the two groups (p = .03) (Table 4) (Figure 2).

DISCUSSION

CABG can be associated with poor sleep quality which impairs patients’ physical function, emotional well-being, and quality of life (3,4). Sleep disturbance is prevalent in the first 8 weeks after CABG surgery and sometimes lasts for even 6 months (13,16). CPB can cause body organ malperfusion and dysfunction (17–19). Loss of pulsatility of pump flow is one of the items which may be responsible for organ malperfusion (20,21) and worse blood microcirculation (11,22). It is still controversial whether maintaining pulsatile flow is associated with less end-organ damage or not (23,24). Shepard et al. (25) have concluded that with the same mean arterial pressure, pulsatile flow may generate 3.4 times more energy that may be reason for better peripheral blood circulation. Specific effect of pulsatile flow on cerebral perfusion is also controversial, and it is still not clear whether pulsatile flow has protective effect on brain while the patient is on pump (26–28).
The most physiologic blood flow pattern can be generated by ventricular pumps, but as they are expensive and technologically complex, roller pumps are more usually used to produce pulsatile flow (29). With the new roller heart–lungs machines, it is easy to convert nonpulsatile blood flow to pulsatile blood flow by adjusting pulsatility indexes such as base flow, start time, stop time, and pulse rate. The more the base flow, the less will be the pulsatile

Table 1. Patient characteristics of both groups (independent t-test).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nonpulsatile Blood Flow</th>
<th>Pulsatile Blood Flow</th>
<th>Independent t-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>t df p Value</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td>50.2 7.9</td>
<td>52.8 8.2</td>
<td>1.11 45 .27</td>
</tr>
<tr>
<td>BMI</td>
<td>25.3 3.9</td>
<td>26.5 4.7</td>
<td>.99 45 .32</td>
</tr>
<tr>
<td>Aortic cross clamp duration (minutes)</td>
<td>43.3 8.3</td>
<td>40.5 10.8</td>
<td>1.02 45 .31</td>
</tr>
<tr>
<td>Cardiopulmonary bypass duration (min)</td>
<td>73.4 15.5</td>
<td>66.9 19.4</td>
<td>1.28 45 .21</td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>2.2 1.6</td>
<td>2 .7</td>
<td>.92 45 .36</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>8.1 2.5</td>
<td>7.2 1.8</td>
<td>1.42 45 .16</td>
</tr>
</tbody>
</table>

Table 2. Patient variables of both groups (chi-square test; The Fisher exact test was used for evaluating hyperlipidemia).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nonpulsatile Blood Flow</th>
<th>Pulsatile Blood Flow</th>
<th>Chi-Square Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number Percentage</td>
<td>Number Percentage</td>
<td>$\chi^2$ df p Value</td>
</tr>
<tr>
<td>Female</td>
<td>7 29.2</td>
<td>5 27.1</td>
<td>.34 1 .56</td>
</tr>
<tr>
<td>Male</td>
<td>17 70.8</td>
<td>18 72.8</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>7 29.2</td>
<td>9 39.1</td>
<td>.47 1 .47</td>
</tr>
<tr>
<td>Hypertension</td>
<td>6 25</td>
<td>8 34.8</td>
<td>.46 1 .46</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>5 20.8</td>
<td>3 13</td>
<td>.37 1 .37</td>
</tr>
<tr>
<td>Smoking</td>
<td>8 33.3</td>
<td>6 26.1</td>
<td>.59 1 .59</td>
</tr>
</tbody>
</table>
flow. A low base flow and a short systolic time can produce better pulsatility but are associated with increased risk of hemolysis because of accelerated speed (30). Pulsatility can be produced either in arrest time (asynchronous mode) or throughout the CPB time which is electrocardiography gated and synchronous to the patient’s natural heart rate.

In literature review, authors did not find any previous study evaluating the impact of pulsatile pump flow on postoperative sleep quality. In this study, we compared the effect of pulsatile and nonpulsatile blood flow on post-CABG sleep quality. The pulsatile flow was adjusted to base flow 30%, pulse width 40%, and frequency 70 bpm. Pulsatile flow was only used during the cardiac arrest time. Considering that there are many confounding factors affecting postoperative sleep quality, we tried to uniform the groups and omit any confounding factors such as blood pressure fluctuation during pump time, preoperative sleep quality difference, depression, usage of antipsychotic or antidepressant drugs, chronic alcohol consumption, addiction, and prior stroke or TIA. Results showed that there was no significant difference between the two groups in terms of patient characteristics (age and gender), cardiovascular risk factors (diabetes mellitus, hypertension, hyperlipidemia, smoking, BMI, and preoperative EF), and preoperative sleep scores. Evaluating postoperative sleep quality 1 month after CABG showed that patients who had pulsatile blood flow had a statistically significant better sleep quality. Although both groups experienced negative change in sleep quality postoperatively, the nonpulsatile group experienced much more sleep disturbance than the pulsatile flow group. As we know, pulsatile flow can be used even throughout the pump time while the heart is beating and arrested (9); we recommend evaluating postoperative organ malfunction and sleeping disturbance with whole time pulsatile flow.

**CONCLUSION**

Using pulsatile flow cardiopulmonary bypass can effectively decrease postoperative sleep disorders in comparison to nonpulsatile flow.

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**REFERENCES**

