Hemodynamic Effects of Osteopathic Manipulative Treatment Immediately After Coronary Artery Bypass Graft Surgery

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Context: Coronary artery bypass graft (CABG) surgery is a common procedure for patients with coronary artery disease. The physiologic effects of postoperative osteopathic manipulative treatment (OMT) following CABG have not been documented previously.

Objective: To determine the effects of OMT on cardiac hemodynamics post-CABG surgery.

Design: Pilot prospective clinical study (N=29).

Setting and Patients: Treatment subjects (n=10) undergoing CABG surgery were recruited for postoperative OMT. The primary assessment compared, pre-OMT versus post-OMT, measurements of thoracic impedance, mixed venous oxygen saturation (SvO₂), and cardiac index. Records of control subjects (n=19) who underwent CABG surgery—but who did not receive OMT—were assessed for SvO₂ and cardiac index at 1 hour and 2 hours postsurgery.

Intervention: Immediately following CABG surgery (<2 h), OMT was provided to subjects to alleviate anatomic dysfunction of the rib cage caused by median sternotomy and to improve respiratory function. This adjunctive treatment occurred while subjects were completely anesthetized.

Results: A post-OMT increase in thoracic impedance (P≤.02) in OMT subjects demonstrated that central blood volume was reduced after OMT, suggesting an improved peripheral circulation. Mixed venous oxygen saturation also increased (P≤.05) after OMT. These increases were accompanied by an improvement in cardiac index (P≤.01). Comparisons of postoperative measurements in OMT subjects versus those in control subjects revealed statistically significant differences for SvO₂ (P≤.005) and cardiac index (P≤.02) between the two groups.

Conclusion: The observed changes in cardiac function and perfusion indicated that OMT had a beneficial effect on the recovery of patients after CABG surgery. The authors conclude that OMT has immediate, beneficial hemodynamic effects after CABG surgery when administered while the patient is sedated and pharmacologically paralyzed.

Diseases of the heart rank as the number one cause of death in the United States, and coronary artery disease accounts for the majority of the morbidity and mortality associated with such pathological conditions. Coronary artery bypass graft (CABG) surgery is performed worldwide approximately 800,000 times per year on patients with coronary artery disease. A number of postoperative complications after CABG surgery, including arrhythmia, atelectasis, cerebrovascular accident, myocardial infarction, and pneumonia can increase morbidity and prolong patients’ hospital stays. Many studies have evaluated interventions to decrease complications and quickly return patients to pre-morbid functioning. Such adjunctive therapies have included rapid extubation post-CABG surgery, postoperative incentive spirometry, and normothermic versus hypothermic perfusion during CABG surgery. Mechanical and pharmacologic reductions of inflammatory mediators have also been investigated.

The objective of the present pilot study was to assess the physiologic effects of postoperative osteopathic manipulative treatment (OMT) immediately after CABG surgery. Objective measurements of improved respiration and, therefore, movement of lymphatic fluid following OMT have previously been difficult to document. We analyzed trends in central blood volume as a gauge for fluid accumulation in the chest, allowing us to quantify the effects of postoperative OMT in unconscious, pharmacologically paralyzed cardiac patients. Our analyses documented the acute beneficial effects of OMT on changes in cardiac hemodynamics as assessed by thoracic impedance, mixed venous oxygen saturation (SvO₂), and cardiac index.

Materials and Methods
The Institutional Review Board of the University of North Texas Health Science Center (UNTHSC) at Fort Worth...
approved this pilot prospective clinical trial and the trial’s informed consent forms. In the OMT arm of the trial, subjects (56 to 74 years old) scheduled to undergo CABG surgery were recruited regardless of ethnic background. Subject recruitment was conducted from a pool of patients undergoing CABG surgery requiring median sternotomy. Explanations were provided to the subjects before the subjects signed informed consent forms. The treatment group (n=10) underwent CABG surgery and received postoperative OMT. Selected by a chart review, subjects in the control group (n=19), who underwent CABG but did not receive postoperative OMT, were also assessed. The age range of these subjects was 56 to 79 years.

Subjects in both groups were evaluated for the comorbid conditions of diabetes mellitus, recent myocardial infarction, and chronic obstructive pulmonary disease. In the subjects receiving OMT, thoracic impedance, SvO₂, and cardiac index were measured prior to CABG surgery; immediately after (≤2 h) surgery (and 5–10 min prior to postoperative OMT); and 5 to 10 minutes after cessation of postoperative OMT (which lasted 25–30 min). In the control group subjects, SvO₂ and cardiac index were measured prior to CABG surgery, at 1 hour postsurgery, and at 2 hours postsurgery. Thoracic impedance was not measured and therefore not available in the control group.

### Surgical Instrumentation and Anesthesia

Prior to surgery, all subjects in the treatment and control groups were intravenously premedicated with the following weight-dependent dosages: 0.7 mg/kg ranitidine, 2–4 µg/kg glycopyrrolate, 0.7 mg/kg diphenhydramine, and 20–40 µg/kg midazolam. Monitoring lines were placed in each subject; these lines included a radial arterial catheter, a central venous jugular line introduced with a continuous cardiac output catheter (Swan-Ganz catheter; Abbott Laboratories, Abbott Park, Ill), and one or two large-bore peripheral venous canulae. General anesthesia was induced by 1–2 mg/kg propofol, 0.7–2.0 µg/kg sufentanil, and 0.1 mg/kg vecuronium. Following endotracheal intubation, general anesthesia was maintained with oxygen and sevoflurane. Throughout surgery, additional narcotic was administered to maintain sedation and relaxation.

### Coronary Artery Bypass Graft Surgery

All subjects underwent primary CABG surgery using the internal mammary artery and reverse saphenous vein. Upon initiation of cardiopulmonary bypass, the subjects were maintained moderately hypothermic (34°C/93°F) during the period of aortic cross-clamping. Initial cardiac arrest was completed by using antegrade blood cardioplegia solution, followed by retrograde blood cardioplegia solution. In addition, all subjects received full doses of aprotinin, as well as strategic leukocyte filtration. Three drainage tubes—two mediastinal and one left pleural—were placed in each subject. The chest was closed in the usual manner, with 5-gauge stainless steel wire for the sternum and a multilayered absorbable suture for the rest of the closure.

### Measurements of Thoracic Impedance

Prior to surgery, each subject in the OMT arm of the trial was instrumented with four electrocardiograph leads for measuring thoracic impedance, two on the anterior and posterior

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**Table**

Osteopathic Manipulative Treatment After Coronary Artery Bypass Graft Surgery: Demographic Variables of Subjects and Procedures (N=29)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment Group (n=10)</th>
<th>Control Group (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>8 (80)</td>
<td>13 (68)</td>
</tr>
<tr>
<td>Women</td>
<td>2 (20)</td>
<td>6 (32)</td>
</tr>
<tr>
<td>Age, Mean (Range), y</td>
<td>64 (56–74)</td>
<td>68 (56–79)</td>
</tr>
<tr>
<td>Comorbid Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>3 (30)</td>
<td>9 (47)</td>
</tr>
<tr>
<td>Recent myocardial infarction</td>
<td>4 (40)</td>
<td>2 (11)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>2 (20)</td>
<td>4 (21)</td>
</tr>
<tr>
<td>Duration of Surgical Procedure, Mean ± SD, min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiopulmonary bypass</td>
<td>98 ± 16</td>
<td>86 ± 24</td>
</tr>
<tr>
<td>Aortic cross-clamping</td>
<td>61 ± 12</td>
<td>51 ± 12</td>
</tr>
</tbody>
</table>

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**ORIGINAL CONTRIBUTION**

O-Yurvati et al • Original Contribution
of the midbelly of the left sternocleidomastoid muscle and two in the opposite contralateral midaxillary line of the lower thorax, at the seventh and eighth intercostal spaces. The location of the initial lead placement was marked on each subject to ensure accurate replacement if necessary.

Thoracic impedance was determined by passing a small electric current (200 µA) from the outside electrodes to the inside electrodes and measuring the impedance (C-Guard thoracic impedance monitor; Danmeter, Odense, Denmark) between the inside electrodes. The impedance measurements were used as an indicator of central blood volume; when central blood volume is reduced, impedance increases due to the current’s decreased ability to be transmitted through the tissues of the chest. An increase in thoracic impedance suggests a change in fluid distribution consistent with a decrease in intrathoracic fluid volume and redistribution to peripheral circulation.

Thoracic impedance measurements were made for each OMT subject immediately after surgery (and prior to postoperative OMT) and again immediately after cessation of OMT. The postoperative measurements were made with the subjects supine, unconscious, pharmacologically paralyzed, and ventilated. Thoracic impedance was not measured in the control group.

**Measurements of Mixed Venous Oxygen Saturation**

In each OMT and control subject, a catheter was used for determination of SvO₂, an indicator of peripheral oxygen consumption. Prior to surgery, the catheter was inserted into either the subclavian vein or internal jugular vein, then into the pulmonary artery. This procedure is a common practice at the UNTHSC in all cardiac surgeries for measurement of cardiac function. The catheter was removed, as per the usual protocol, 24 hours postoperatively.

Measurements of SvO₂ were made for each OMT subject immediately after surgery (and prior to postoperative OMT) and again immediately after cessation of OMT. Measurements of SvO₂ were collected from the chart review for each control subject: the first at 1 hour after surgery and the second at 2 hours after surgery. The postoperative measurements were made with the subjects supine, unconscious, pharmacologically paralyzed, and ventilated.

**Measurements of Cardiac Index**

In each subject, a catheter was used for determination of cardiac index, an indicator of cardiac function that reveals the amount of blood ejected by the left ventricle into systemic circulation in 1 minute, divided by the body’s surface area. We used the following formula to calculate cardiac index: cardiac index = cardiac output (L/min) / body surface area (m²).

Cardiac index measurements were made for each OMT subject immediately after surgery (and prior to postoperative OMT) and again immediately after cessation of OMT. Cardiac index measurements were collected from the chart review for each control subject: the first at 1 hour after surgery and the second at 2 hours after surgery. The postoperative measurements were made with the subjects supine, unconscious, pharmacologically paralyzed, and ventilated.

**Postoperative Osteopathic Manipulative Treatment**

Postoperative OMT was performed by two of the authors (A.H.O-Y., M.S.C.) to alleviate anatomic deformation of the rib cage caused by median sternotomy and to improve respiratory breathing mechanics. With the subjects supine, unconscious, and pharmacologically paralyzed, osteopathic physicians performed gentle manipulation of the thoracic myofascial tissue and rib cage, including indirect myofascial and localized lymphatic pump techniques, in an attempt to improve lymphatic flow away from congested tissues and to balance ligamentous tension. The OMT providers used sterile procedures while touching the patients near the surgical sites.

The OMT provided to the subjects, in either the surgical intensive care unit or the recovery room, included various techniques established in the osteopathic medical profession.\(^\text{10,11}\) With regard to the sequence of treatment, though the sequence was not done according to a protocol, the similarity of the acute somatic dysfunctions in the immediate postoperative period was such that patient treatment was usually done by treating the thoracic spine and ribs first, the diaphragm next, the sternum third, and the upper cervical region last. The significant strain associated with the necessary spreading of the anterior thoracic cage and sternum demanded that most of the treatment time be spent on the thoracic spine and ribs. Among the techniques used were the following:

- **Balanced ligamentous tension**—The osteopathic physician placed both hands under the patient’s back beneath the bed sheet and contacted the spinous processes of the thoracic vertebrae and posterior ribs, feeling for ligamentous tension. Very gentle pressure and minor movements of the vertebrae and ribs were applied until a point of balanced tension was felt and strain was released.

- **Indirect myofascial release of the sternum**—The osteopathic physician placed one hand under the sternum and the other hand on top of the patient, over the sternum. In some cases, the hand over the sternum was positioned over the dressing of the sternal wound; in other cases, the fingertips were placed on either side of the sternal wound. The osteopathic physician’s hands applied gentle pressure until the point of ease of the fascia was felt.

- **Indirect release of the respiratory diaphragm**—The application of this procedure was similar to that of the previous procedure, but with the osteopathic physician’s hands positioned lower down the back (at the thoracolumbar junction) and over the xiphoid-epigastric area. Gentle pressure was applied to feel the diaphragmatic myofascial tension, with release as in the previous technique.
Occipito-atlantal decompression—The osteopathic physician contacted the posterior base of the skull (occiput) with fingers of both hands and applied gentle superior, posterior, and lateral pressure traction. This was done to release tension between the occipital condyles and the first cervical vertebra (atlas) within the occipito-atlantal articulation.

Rib raising—From the head of the bed, the osteopathic physician’s hands were slid under the patient’s upper back, contacting the rib heads at the thoracic level, T1–T5. Upward and lateral pressure was then applied.

Sibson’s fascial release—From the head of the bed, the operator’s thumbs contacted Sibson’s fascia bilaterally posterior to the clavicles and pressed caudally to stretch the fascia. Care was taken to avoid disturbing any intravenous lines.

To analyze the statistical data resulting from OMT in subjects, as well as the data generated for the control subjects, we used GraphPad’s Prism statistical program (GraphPad Prism3; GraphPad Software Inc, San Diego, Calif). The statistics evaluated included mean, SE, and t test (paired and unpaired).

Results
Subjects participating in the present study had the typical demographics for patients undergoing CABG surgery.12 The group was predominately male and had several comorbid conditions (Table). In addition, the durations of surgical procedures were typical for CABG surgery, with cardiopulmonary bypass lasting approximately 90 minutes, and aortic cross-clamping lasting approximately 1 hour (Table).

The present study found beneficial hemodynamic effects of postoperative OMT in treatment subjects as assessed by three different measurements—thoracic impedance, mixed venous oxygen saturation, and cardiac index (Figures 1 through 3).

In a comparison of pre-OMT thoracic impedance with
cant by a 2-tailed test for paired samples ($t = 3.10, P \leq .02$).

In a comparison of pre-OMT SvO2 values with post-OMT SvO2 values in subjects who received OMT (Figure 2), the mean SvO2 value increased from 66.9% (95% CI, 64.3–69.5%) to 70.6% (95% CI, 68.2–73.0%). This increase was significant by a 2-tailed test for paired samples ($t = 3.66, P \leq .005$).

The OMT-induced improvements in subjects’ thoracic impedance and SvO2 were accompanied by a statistically significant improvement in cardiac index. In a comparison of pre-OMT cardiac index values with post-OMT cardiac index values in subjects who received OMT (Figure 3), the mean cardiac index value increased from 2.86 (95% CI, 2.70–3.02) to 3.37 (95% CI, 3.19–3.55). This increase was significant by a 2-tailed test for paired samples ($t = 4.07, P \leq .01$).

The positive changes in SvO2 and cardiac index observed for postoperative subjects treated with OMT were compared with the changes in SvO2 and cardiac index—as measured at 1 hour and 2 hours postsurgery—for patients not receiving OMT (Figures 4–5). Whereas the change in the SvO2 mean observed for the OMT subjects was 3.7% (95% CI, 2.69–4.71%), the change in the mean observed for the control subjects was actually negative: $-3.28\%$ (95% CI, $-4.88\%$–$-1.68\%$) (Figure 4). A 2-tailed test for unpaired samples found a significant difference in parameter change between the treatment and control groups ($t = 3.05, P \leq .005$). In contrast, cardiac index showed improvement in both the treatment and control groups, but the improvement was greater in the OMT-treated subjects (Figure 5). The change in the cardiac index mean for the OMT subjects was 0.51 (95% CI, 0.38–0.64), while the change in cardiac index mean for the control subjects was only 0.14 (95% CI, 0.06–0.22). A 2-tailed test for unpaired samples found a significant difference in parameter change between the treatment and control groups ($t = 2.56, P \leq .02$).

**Comment**

The present pilot study demonstrated that OMT had immediate physiologic effects following CABG surgery while subjects were sedated and pharmacologically paralyzed. These effects included beneficial, physiologic hemodynamic changes (as measured by cardiac index) and in perfusion (as measured by thoracic impedance and SvO2) following postoperative OMT in the recovery room. These findings were confirmed by comparisons of postoperative changes in cardiac index and SvO2 between OMT-treated subjects and control subjects, who were not treated with OMT: there was a greater positive change in cardiac index in the treatment group, and a positive versus a negative change in SvO2 (for the treatment group versus the control group, respectively).

Thoracic impedance is a noninvasive measurement that exhibits an inverse correlation with central blood volume.$^{13–15}$ As seen in the treated subjects in the present study, increases in thoracic impedance, which indicate a redistribution of blood to the periphery, were accompanied by increases in oxygena-
tion of blood. Both of these increases were positive changes with respect to patient recovery. These changes, coupled with the observed increases in cardiac index in treated subjects, clearly indicate that OMT had a beneficial effect on the cardio-pulmonary system.

Since the OMT-related data in the present study were collected on instrumented patients who were in an unconscious, paralyzed state, we conclude that the observed changes in cardiac hemodynamics were caused by physical manipulation applying osteopathic principles and practice. The changes in hemodynamic parameters were suggestive of a shorter stay in the recovery room and other potential short-term and long-term health benefits.

The medical literature documents the regular use of OMT at some osteopathic institutions and medical centers in the United States within the past 15 to 20 years. For example, Rogers and Starzinski8 noted in 1989 that OMT was "part of a comprehensive treatment protocol" postoperatively for cardio-pulmonary bypass procedures at Detroit Osteopathic Hospital in Highland Park, Mich. Most of the literature supporting the use of OMT for the postoperative patient has focused on anatomic correlation and suggestions for particular procedures.17-21 Nevertheless, investigations of the use of OMT for improving outcomes in hospitalized patients have received increased attention. Radjeski et al22 reported in 1998 that OMT decreased length of stay for patients with acute pancreatitis, and Noll et al23 reported in 2000 that the use of adjunctive OMT in patients hospitalized with pneumonia decreased utilization of oral antibiotic therapy.

The beneficial effects of OMT observed in the present pilot study are likely the result of improvements in fluid homeostasis, including lymphatic fluid flow. The use of manipulative techniques that improve lymphatic flow and restore normal respiratory function can help to relieve fluid accumulation. Disruption of efficient breathing mechanics caused by the anatomic deformation of the chest during cardiac surgery tends to cause postoperative restriction of the normal respiratory mechanism and, therefore, restriction of lymphatic flow.10 The present study lends support to previously published case reports that have indicated that OMT improves fluid homeostasis and speeds recovery in some patients who have undergone median sternotomy or other pulmonary surgical procedures.17,24,25

Risks of OMT in the hospital setting are few. Potential and theoretical risks of OMT for patients in the present study included arrhythmia; cerebrovascular accident; infection caused by greater exposure to hospital personnel; dislodging of intravenous lines and pacer wires; dislodging of a thrombus; and the opening of the surgical chest incision, resulting in hemorrhage. None of these outcomes presented themselves in this study of 29 subjects. Such risks are generally avoidable when osteopathic physicians take appropriate care in applying treatment.

The present pilot study demonstrates short-term hemodynamic benefits of OMT following CABG surgery, one of the most high-risk and costly medical procedures performed in the United States. The findings of positive effects of OMT shortly after CABG surgery suggest that OMT has the potential to reduce some of the acute adverse effects of CABG surgery. The present study also suggests other potential benefits of OMT for patients who have undergone CABG surgery. These benefits include: (1) possible reduction in pulmonary complications (such as atelectasis and pneumonia); (2) possible reduction in length of stay in the hospital; and (3) possible decreased risk of fluid mismanagement, a problem that can lead to pulmonary edema or renal compromise.

References


