The Effect of Osteopathic Manipulative Treatment on Postoperative Medical and Functional Recovery of Coronary Artery Bypass Graft Patients

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Context: Several studies have investigated the use of osteopathic manipulative treatment (OMT) after coronary artery bypass graft (CABG) operations; however, there is little information regarding the effect of OMT in the postoperative recovery of patients undergoing CABG operations.

Methods: Patients scheduled to undergo a CABG operation were voluntarily enrolled and randomly assigned to receive 1 of 3 treatment protocols after their surgical procedure: standardized daily OMT and conventional postoperative care (the OMT group), daily time-matched placebo OMT and conventional postoperative care (the placebo group), or conventional postoperative care only (the control group). Specific OMT techniques used were thoracic inlet myofascial release, standard rib raising (with paraspinal muscle stretch to the L2 vertebral level), and soft tissue cervical paraspinal muscle stretch (with suboccipital muscle release). Primary outcome measures included time to discharge, time to postoperative bowel movement, and FIM functional assessment scores.

Results: Fifty-three patients completed the study protocol: 17 in the OMT group, 18 in the placebo group, and 18 in the control group. After surgical procedures, patients were discharged to home at a mean (standard deviation [SD]) rate of 6.1 (1.4), 6.3 (1.5), and 6.7 (3.0) days for the OMT group, placebo group, and control group, respectively. Patients in the OMT group were discharged 0.55 days earlier than those in the control group and 0.16 days earlier than those in the placebo group. The mean (SD) number of days to first postoperative bowel movement was 3.5 (0.9), 4.0 (0.8), and 4.0 (0.9) for the OMT group, the placebo group, and the control group, respectively. On day 3 after surgery, the mean (SD) total score on the FIM was 19.3 (6.7), 15.4 (7.3), and 18.6 (6.5) for the OMT, the placebo, and the control group, respectively; total score for the OMT group was 0.81 greater than that of the control group and 3.87 greater than that of the placebo group. None of the differences achieved statistical significance ($P<.05$)

Conclusion: A daily postoperative OMT protocol improved functional recovery of patients who underwent a CABG operation.

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Accsording to 2009 data from the National Center for Health Statistics, 415,000 persons underwent coronary artery bypass graft (CABG) operations in the United States, a decrease of approximately 22,000 persons from 2004.[1,2] This decrease may be due to percutaneous interventions.[3] A search of the US National Library of Medicine's PubMed database conducted in January 2003 for the keywords "CABG," "OMT," "function," "discharge planning," and "length of stay" showed that very little inquiry has been performed regarding the effect of osteopathic manipulative treatment (OMT) after CABG surgical procedures. Dickey[4] discussed specific techniques refined from personal experience treating patients who had undergone sternotomy and CABG. His experience, however, was limited to a few patients, and treatment began at least 3 weeks after a surgical procedure in most instances. Responding to Dickey's work, Rogers and Starzinski[5] reported their experience using OMT to treat patients early in the recovery phase after open heart surgery and discussed the importance of lymphatic pump, rib raising, and diaphragmatic release techniques. In 1989, when they made their comments, a comprehensive treatment protocol had been in place for 10 years, one that recommended that patients at their institution receive early postoperative OMT.[5] Johnson[6] also discussed specific treatments for patients with cardiac disease but did not address postoperative treatment. A 2005 study by O-Yurvati[7] tested the hemodynamic effects of OMT immediately after CABG operations but did not study the effect of OMT on functional recovery.

The relationship of sympathetic control over the heart originating from the sympathetic chain ganglia at T1-T5 has been extensively researched,[8-10] and compilations of this work have been assembled for a quick review.[11] Many researchers[12-20] have shown the strong correlation of somatic dysfunction in the upper thoracic area and upper ribs, consistently noting left-sided T1-T4 dysfunction, as well as C2 dysfunction, occurring in patients with known cardiovascular disease. We did not, however, find studies outlining the postoperative effect of OMT on patients who underwent sternotomy operations.

In the current study, we investigated the effect of OMT in the postoperative recovery of patients who underwent CABG operations. We hypothesized that patients treated with an OMT protocol from day 1 after a CABG operation until discharge to home would have a bowel movement and be discharged sooner than patients receiving sham OMT or no OMT. We also hypothesized that the patients receiving OMT would show increased FIM (formerly known as the Functional Independence Measure) scores.

Methods

Experimental Design

Our prospective, randomized, double-blinded, placebo-controlled pilot trial examined the effect of OMT on patients who underwent elective CABG operations. The study was conducted at a community-based, university-affiliated teaching hospital during 35 consecutive months, from January 2003 through June 2005. All patients received care consistent with national standards for post-CABG care.[21] The sole experimental intervention was the addition of either actual or placebo OMT to standard care. The hospital's institutional review board and the Michigan State University Committee for Research Involving Human Subjects approved all research activities in advance.

Patients

Patients aged 18 to 80 years who were designated to undergo elective CABG surgery were recruited from the practice of an osteopathic cardiovascular surgeon (G.L.R.). All patients provided informed consent, and enrollment was voluntary. Participants were randomly assigned by means of computerized number generation to receive 1 of 3 postoperative treatment protocols: standardized daily OMT and conventional postoperative care (ie, the OMT group), daily time-matched placebo

OMT and conventional postoperative care (ie, the placebo group), and conventional postoperative care only (ie, the control group). Exclusion criteria included prior CABG surgical procedure, unstable psychiatric illness or chronic pain, open chest phenomenon, and unforeseen peri- or postoperative complications. If a patient in the OMT or placebo group did not receive a scheduled treatment, he or she was dropped from the study.

Intervention

Numerical identifiers were used to blind patients, hospital direct caregivers, and data collectors to the treatment group assignment. Treatment began on the first postoperative day and continued on a once-a-day basis until discharge to home. Each treatment session was performed by osteopathic physicians or osteopathic medical students supervised by 1 of the physician coauthors with an emphasis in OMT and at least 2 years of osteopathic medical school completion (ie, J.M.W., C.B., S.G., L.D., or J.R.). All those involved in the treatment of patients also underwent specific training in the selected OMT and placebo treatment protocol for standardization of technique. The 2 training sessions each lasted 1 hour, were conducted by 1 physician-instructor (S.G.), and took place at a local hospital (Ingham Regional Medical Center). The 8-minute protocol consisted of 3 manipulative techniques, all of which were performed with the patient in a supine position, with the head of the bed inclined less than 45°.

The OMT techniques were chosen to regulate and balance the sympathetic and parasympathetic nervous systems and improve lymphatic drainage of the thorax and mechanical motion of the thoracic cage. We chose these techniques on the basis of altered rib cage function influencing respiratory, circulatory (arterial, venous, and lymphatic), and neural activity (particularly of the intercostal nerves and the brachial plexus superior to rib 1).

Technique 1: Thoracic Inlet (Indirect) Myofascial Release

1. With the patient lying supine, the operator placed his or her thumbs over the T1 transverse processes posteriorly and his or her fingers on the patient's clavicle and first 2 ribs anteriorly.

2. With full hand contact, the operator compressed and then sheared the tissues in an anterior/posterior, clockwise/counter-clockwise direction.

3. The operator maintained contact with the tissues in a direction of ease until the release was appreciated.[22(p163)]

The thoracic inlet, at the superior opening of the rib cage, is bordered by the T1 vertebral body posteriorly, the medial margins of the first ribs bilaterally, the posterior aspect of the manubrium, and the medial end of both clavicles anteriorly.[22(p163)] The thoracic duct, carrying lymph from the left upper body quadrant and the entire lower half of the body, empties into the left internal jugular and subclavian veins immediately posterior to the medial end of the clavicle and first rib on the left. The right lymphatic duct carries lymph from the right upper quadrant of the body and empties into the right subclavian vein, usually at its junction with the right internal jugular vein. Therefore, it is paramount to treat the thoracic inlet first to allow proper lymph drainage into the venous system. Myofascial release of the thoracic inlet improves lymphatic drainage by loosening connective tissue structures around this junction site, improving mechanical motion of the upper ribs.[23] Impaired lymphatic flow increases central venous pressure, leading to tissue congestion and peripheral edema.[24,25] In congested tissue, oxygen and nutrients exchange poorly, leading to derangement. For example, endocardial fibrosis has been associated with chronically impaired cardiac lymph flow.[26]

Technique 2: Rib Raising With Continued Stretch of the Paraspinal Muscles to the L2 Vertebral Level

1. The operator placed his or her hands under the patient's thorax, contacting the rib angles with the pads of the fingers beginning with rib 1.

2. The operator applied gentle traction in an anterior/lateral direction with flexed fingers.

3. When the muscles softened, the operator repositioned his or her hands on the next-lower area of the thorax.

4. When the thorax treatment was complete, the operator applied gentle traction in an anterior/lateral direction to the paralumbar muscles at the L1 and L2 spinal levels, similar to the previous steps.

5. The operator repeated steps 1 to 4 on the contralateral side of the thorax and upper lumbar area (William J. Pintal, DO, oral communication, 2004).

Rib raising is aimed at improving the mobility of the rib cage, increasing lymphatic drainage, and regulating sympathetic tone. This tone is modified through the sympathetic chain ganglia, which lie anterior to the rib heads. Treatment at the T1-T6 vertebral level provides sympathetic input to the heart and lungs, whereas treatment at the T5-L2 vertebral level provides input to the entire gastrointestinal system, as reported by various investigators.[6,8,9,11,12,14,17-19,27] Palpatory changes of somatic dysfunction at the T1-T5 vertebral level on the left or right side have shown a 73%-79% accuracy compared with angiography in detecting coronary vascular disease.[17,19] By regulating sympathetic tone, it is possible to decrease heart rate, vasoconstriction, cardiac irritability (thus affecting arrhythmias), coronary artery spasm, bronchial constriction, and pulmonary secretions, and to improve lymphatic drainage and increase gastrointestinal mucosal defenses (against digestive acids and enzymes) by combating the vasoconstriction and alteration of mucous buffers.[15,24,28-33] Continued stretch of the paraspinal mus-

cles of the L1-L2 vertebral levels encompasses the entire sympathetic nervous system of the gastrointestinal tract to assist in obtaining the above results. In addition, treatment of L1 and L2 paraspinal muscles will also affect the diaphragm via the attachments of the crura.

Technique 3: Soft Tissue Cervical Paraspinal Muscle Stretch With Suboccipital Muscle Release

1. The operator placed the pads of his or her fingers medial to the patient's cervical paraspinal muscles close to the spinous processes.

2. The operator then applied gentle pressure in an anterior/lateral direction.[34]

3. The operator performed suboccipital release by placing his or her finger pads just inferior to the superior nuchal line.

4. The operator sustained a gentle, constant pressure with gentle cephalic traction and with his or her fingers elevating the patient's head.

5. The patient's head was allowed to slowly descend toward the operator's palms as suboccipital muscles softened.[34]

RATIONALE FOR CERVICAL PARASPINAL MUSCLE STRETCH
WITH SUBOCCIPITAL MUSCLE RELEASE

Paracervical stretch reduces muscle hypertonicity from somatic dysfunction that may result from respiratory intubation and perioperative head placement—which may certainly involve the C3-C5 nerve root levels (the origins of the phrenic nerve).

RATIONALE FOR SUBOCCIPITAL MUSCLE RELEASE

The vagus nerve exits the cranium via the jugular foramen, passing inferiorly through the neck within the carotid sheath between the internal carotid artery and the internal jugular vein, and supplying parasympathetic input to the internal organs of the neck, thorax, and abdomen. Suboccipital release or inhibition may aid in regulating parasympathetic tone. Because hyperpara-

sympathetic tone can cause bradyarrhythmia via the sinoatrial node (right vagus) and heart block via the atrioventricular node (left vagus), hypotension, decreased atrial contraction, ventricular contractility, and coronary blood flow can influence gastrointestinal motility. Suboccipital muscle release technique is aimed at reducing these problems.[15,24,32] Specific dysfunctions of the occipital mastoid suture, CO-C1 (occipitoatlantal) and C1-C2 (atlantoaxial) joints, or C2 (where significant vagal communications exist) may produce undesirable effects via afferent activation of vagal reflexes.[24]

The placebo group received a sham therapy protocol of light-touch hand placement that did not move myofascial structures. Operators applied sham therapy to the same body regions as the OMT that lasted for the same duration and frequency as the OMT. Training in sham therapy was concurrent with the training in the OMT protocol and was conducted by the same physician-instructor (S.G.).

The control group received conventional postoperative care only, without OMT.

Measures and Outcomes

Baseline data, logged on an intake questionnaire at the time of enrollment into the study before randomization, included demographic characteristics, past medical and surgical history, and medications. Demographic variables included date of birth, age, and sex.[35] A FIM-certified physical therapist, blinded to group designation, performed a medical record review and entered data points into table form in Microsoft Excel (version 1997-2003, Microsoft Corp). The medical record review included date of the CABG operation, number of blood vessels bypassed, date extubated, surgical complications, total length of hospital stay, the number of postoperative days until discharge, record of OMT or placebo treatments, supplemental oxygen needs, date of first bowel movement, distance walked, and analgesia usage during hospital stay. Components of the FIM, the functional assessment measure of the Uniform Data System for Medical

Rehabilitation, were used to assess patients' functional independence.[36] The FIM instrument includes a 7-point scale that measures major nonlinear gradations in function and degree of disability, assessing what a person is able to do with reasonable safety vs his or her need for assistance from another person or from an assistive device. The FIM tasks evaluated included grooming, toileting, transfers, and walking. Each task was rated on a 7-point scale representing different gradations of independence and the amount of assistance required to perform a specific activity. For each patient, we recorded a FIM score out of a total of 28 points, with a higher score indicating greater functional independence. The primary outcome measures were number of postoperative days to discharge, number of days until return of bowel function, and FIM scores. Because the most complete data set was gathered from patients by postoperative day 3 (eg, some patients began to be discharged to home on day 4), only total FIM score on postoperative day 3 is reported here.

Statistical Analysis

Descriptive statistics and statistical analyses comparing the 3 groups were coordinated by a statistician blinded to the patient group assignment by using an Excel spreadsheet (version 1997-2003, Microsoft Corp) and Minitab statistical software (version 16, Minitab Inc) with α set to .05. For each outcome variable, the 3 group means and standard deviations (SDs) were compared with F tests, and cross tabulations were evaluated with χ^2 tests. After the groups were identified, 2-sided t tests were used to compare the OMT group outcomes with the control group outcomes. Power analyses were calculated to plan the optimal sample sizes for subsequent studies comparing the 3 treatment groups.

Results

Eighty-one patients were enrolled on a voluntary basis. Fifty-three patients—18 from the OMT group, 17 from the placebo group, and 18 from the control group—com-

Table 1.
Postoperative CABG Patient Characteristics:
Means, Standard Deviations, and Counts

Patient Characteristics, No.[a]	Group		
	OMT (n=17)	Placebo (n=18)	Control (n=18)
Age, y (mean [SD])	65.1 (1.7)	67.0 (10.9)	63.3 (7.7)
Vessels bypassed, No. (mean [SD])[b]	3.2 (1.3)	3.4 (0.8)	2.4 (1.0)
Length of hospital stay, d (mean [SD])	8.6 (3.2)	9.3 (2.5)	8.9 (4.4)
Male	13	13	14
Diabetes	6	7	7
Diabetic neuropathy	0	0	1
History of CAD	11	9	12
Current tobacco use	2	5	4
Smoking history	11	8	11
COPD	0	0	2
CVA/TIA history	2	0	0
CHF	0	0	2
GERD	0	1	2
Osteoarthritis	3	2	5
Fibromyalgia/chronic pain	0	1	0
Paresthesias	0	1	3
Lumbar or thoracic surgery	3	1	3
Trauma to lumbar or thorax	1	2	1
Prior OMT or chiropractic treatment	8	11	10

[a] Data are presented as No. except where otherwise noted.
[b] The only patient characteristic showing a statistically significant difference in means across the 3 cohorts (F test, $P<.02$). Alternative χ^2 test of equality of percentages in the categories 1-2 vessels, 3 vessels, and 4 or more vessels results in $P<.02$. Note that the control group had the fewest vessels bypassed on average.

Abbreviations: CABG, coronary artery bypass graft; CAD, coronary artery disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; GERD, gastroesophageal reflux disorder; OMT, osteopathic manipulative treatment; SD, standard deviation; TIA, transient ischemic attack.

pleted the protocol at the time of hospital discharge, and 28 patients were dropped from the study because of 1 missed session. A breakdown of patient demographic traits and other characteristics are found in *Table 1*. The medical record review data we included were number of blood vessels bypassed, surgical complications, number of postoperative days until discharge, date of first bowel movement, and distance walked. Analgesia usage was also reviewed but proved to be an insignificant factor across patient groups.

Data analysis indicates that patients in the OMT group demonstrated decreased length of hospital stay, earlier return of bowel function, and improvements in postoperative function, as indicated by higher FIM

Table 2.
Response Variable Outcomes for Postoperative CABG Patients (N=53)

Response Variable	Mean (SD)			F Test P Value
	OMT Group (n=17)	Placebo Group (n=18)	Control Group (n=18)	
Discharge to home, d	6.1 (1.4)	6.3 (1.5)	6.7 (3.0)	.72
Discharge to home, d[a]	6.1 (1.4)	6.3 (1.5)	6.1 (1.8)	.94
Time to Bowel Movement, d	3.5 (0.9)	4.0 (0.8)	4.0 (0.9)	.19
FIM score on day 3[b]	19.3 (6.7)	15.4 (7.3)	18.6 (6.5)	.22

[a] For this set of data, n=17 for the control group. Data were recalculated excluding the outlying results of 1 patient in the control group, whose time to discharge home was 16 days.
[b] Each task was rated on a 7-point scale, with a total FIM score of 28 representing the greatest functional independence.

Abbreviations: CABG, coronary artery bypass graft; OMT, osteopathic manipulative treatment; SD, standard deviation.

scores compared with the other groups.

Table 2 gives the group means and standard deviations for each response variable for each treatment and the *P* value of the F test of equality of means. The control group included 1 outlier, a patient who was discharged 16 days after the operation. The F test on equality of means was reported for the discharge data with this case removed (with group populations of 17, 18, and 17 for OMT, placebo, and control group, respectively).

Mean (SD) length of stay in the OMT group was 6.1 (1.4) days compared with 6.3 (1.5) days in the placebo group (a difference of 0.2 days) and 6.7 (3.0) days in the control group (a difference of 0.6 days; 2-sided *t* test, *P*=.49). With the outlying patient data removed from the control group data, the mean (SD) for length of stay was 6.1 (1.8) days (n=17) (*Table 2*, *Figure 1*).

Patients in the OMT group also had earlier return of bowel function (*Table 2*, *Figure 2*). Mean time to bowel movement for patients in the OMT group was 0.5 days postoperatively, representing 0.5 days earlier onset of normal bowel function than control patients (2-sided *t* test, *P*=.14). Patients in the placebo group were noted to have a mean time to return of bowel function nearly equal to that of those in the control group.

Patients in the OMT group also had the greatest average total FIM score on postoperative day 3. The mean

score of 19.31 out of 28 exceeds that of the control group by 0.81 (2-sided *t* test, *P*=.72).

With *P*<.05 for the F test for comparing treatment group means for postoperative length of stay in the hospital, a maximum difference in mean lengths of stay of 0.5 days was observed in the study. With a common SD of 1.5 days, 80% power would be achieved with a sample size of 175 per group. For comparing means of time to first bowel movement, a maximum difference in mean (SD) of 0.5 (0.85) days was observed. For these parameter values, 80% power is indicated for a sample size of 57 per group.

Benefits were also shown regarding return of basic mobility, specifically transfers and ambulation—which had their own helpful effect on postoperative recovery. Unanticipated variations in medical record documentation, however, compromised our ability to assess reliably the effect of OMT on other parameters originally considered in the study design, including extubation date, analgesia use, and oxygen needs.

Comment

A basic tenet of osteopathic medicine[37] is that the musculoskeletal system plays a key role in optimal health because it is a direct interface between the patient and the

world in which he or she lives.[38] Osteopathic manipulative treatment, when used in the context of total patient care along with other accepted approaches to care, is part of a systematic approach to health care referred to as osteopathic manual medicine.[38] The design of OMT addresses the fundamental structure-function relationship that is central to mitigating the effects of negative factors that can be altered by optimizing body mechanics. Judicious use of OMT can facilitate health by restoring well-being appropriate to the context of the patient being treated.

Our study presents a clear example of the structure (anatomy)-function (physiology) relationship described by Andrew Taylor Still, MD, DO.[39] When a CABG surgical procedure is performed, there is a preponderance of sympathetic activity negatively affecting gastrointestinal mobility, possibly delaying a bowel movement. By balancing the autonomics with appropriate OMT, bowel activity can potentially be optimized.

The cardiovascular system has been shown to be very responsive to the musculoskeletal system. Some of the best examples of this correlation include the upper thoracic dysfunctions with cardiovascular disease,[17] via the direct influence of rib cage function on arterial, venous, and lymphatic circulation, as well as the effect of somatic dysfunction on cardiac rhythm from sympathetic and parasympathetic tone. A 1976 study by Rogers and Rogers[15] has shown potential changes in autonomic nervous system function in coronary heart disease after OMT is performed.[15] An increased incidence of distinctive segmental patterns of somatic dysfunction has been demonstrated in persons with cardiovascular disease; these changes are palpable in the skin, subcutaneous tissue, and muscle.

The primary goals of OMT for persons with sufficiently advanced coronary artery disease who warrant CABG surgery are (1) to improve lymphatic flow, optimize sympathetic and parasympathetic tone, and gastrointestinal motility, and (2) to hasten return of basic mobility and activities of daily living. We believe that, in light of the interdependence of the cardiovascular and musculoskeletal systems, OMT provides a means for practitioners to augment the initial care provided,
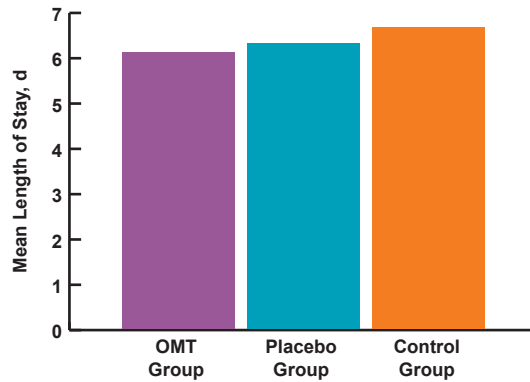

Figure 1.
Length of postoperative hospital stay for patients undergoing coronary arterial bypass graft surgical procedures. *Abbreviation:* OMT, osteopathic manipulative treatment.
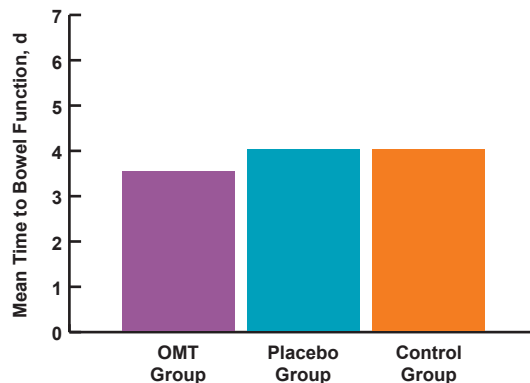

Figure 2.
Time to first postoperative bowel movement for patients undergoing coronary arterial bypass graft surgical procedures. *Abbreviation:* OMT, osteopathic manipulative treatment.

facilitate short postoperative recovery times, decrease postoperative morbidity, and return patients to greater functional independence and resultant safety for routine activity in the shortest time possible. The result of these benefits is the best possible quality of care for patients at a decreased cost for providers and payers.

The present study is a randomized, prospective, double-blinded, placebo-controlled pilot trial. The surgeon, all nursing and other hospital personnel, and research patients, statisticians, and medical record reviewers were

blinded as to which patients were in what cohort. Substantial effort was expended to eliminate, to the greatest extent possible, compounding variables that we considered. Osteopathic examiners could not, of necessity, be blinded; however, each examiner underwent standardized training (in terms of time spent with each patient and the character of hand placement) prior to the outset of the study to decrease the effect of varying OMT approaches. Treatment position was also standardized to minimize effort expenditure and movement on the part of patients. The study involved the patients of only 1 surgeon in an effort to have a more homogeneous population. The patients met specific preoperative criteria and perioperative and postoperative conditions. Patients were evaluated preoperatively in the standardized protocol and were randomly assigned to 1 of 3 cohorts by utilizing a statistically validated mechanism.

Despite positive and encouraging results, there were several limitations to our study. First, several osteopathic physicians and students performed OMT on the patients in our study. We did attempt to decrease the role of variable skills on the OMT provided, however, by providing training to all operators in our study. Second, our study population was limited to 1 surgeon's patients to decrease and counter variables and to standardize the preoperative evaluation and consent process. Third, we confined to the study population persons undergoing elective CABG surgical procedures without other surgical interventions such as valve replacement. We are aware that these limitations in our study sample may decrease the ability to extrapolate these findings to other, more heterogeneous, populations.

To our knowledge, this is the first randomized, prospective, double-blind, placebo-controlled trial of OMT used in the acute postoperative care of CABG surgical patients. Our study demonstrated a favorable effect on length of hospital stay and return of preoperative bowel function. To explore these and other variables further, a trial with larger sample sizes, possibly with patients of multiple surgeons and ideally from multiple institutions, is needed.

Conclusion

A positive relationship between OMT and postoperative recovery of CABG surgical patients has been shown. We hope that, with this and further larger scale investigations, osteopathic physicians and other practitioners will see the benefits of OMT for their patients with advanced cardiovascular disease and will consider it as a standard of therapeutic treatment. The beneficial, though statistically insignificant, effect of OMT on recovery of CABG surgical patients demonstrates the previously hypothesized link between osteopathic principles and practice (with OMT as a key part) and a beneficial therapeutic effect on persons with cardiovascular disease, a segment of the US population that is large now and rapidly increasing.

Acknowledgments

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