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RESEARCH REPORT

The effect of osteopathic manipulative treatment on length of stay in posterolateral postthoracotomy patients: A retrospective case note study

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Abstract *Objective:* This study retrospectively evaluated the effect of OMT on length of stay (LOS) in hospitalized posterolateral postthoracotomy patients.
Methods: Inpatient medical records of patients who received posterolateral thoracotomies with lung resection between 1998 and 2011 were reviewed for demographic data, LOS, thoracotomy surgery data, consultation data excluding osteopathic manipulative medicine, discharge data, and osteopathic manipulative medicine consultation data.
Results: Thirty-eight patients received posterolateral thoracotomies with lung resection; 23 patients received OMT and 15 did not. The mean (standard deviation) LOS was 11.0 (6.8) days (range, 5—29 days) for those who received OMT and 10.4 (5.5) days (range, 3—22 days) for those who did not ($P = .90$). Five patients developed postoperative ileus, and all had received OMT. Patients receiving 2 surgical

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procedures had a longer LOS than those receiving 1 surgical procedure ($P = .002$). Having a decortication performed during the thoracotomy increased LOS by a mean of 6.4 days ($P = .005$). Patients admitted directly to the intensive care unit were more likely to receive OMT than those who were not ($P = .03$).
Conclusion: While there was no difference in LOS, severity of illness was different between patients who received OMT and those who did not. Patients who developed postoperative ileus and most of those admitted directly to the intensive care unit received OMT, suggesting that severity of illness was greater for those who received OMT. Future studies should include a higher subject number in order to stratify for illness severity and also assess the effect of OMT on postoperative pain.

Implications for practice

- Osteopathic manipulative treatment can be used in hospitalized postthoracotomy patients.
- Thoracotomy procedures that included a decortication increased length of stay by more than 6 days.
- The use of osteopathic manipulative treatment in hospitalized postthoracotomy patients may influence length of stay in those patients of a greater illness severity.

Introduction

The effect of osteopathic manipulative treatment (OMT) or manual therapy on postoperative patients has been studied for a variety of surgical procedures, and many studies have shown positive benefits. Goldstein et al.[1] showed a reduction in patient analgesic use between postoperative OMT and postoperative sham manipulative treatment groups when OMT was used in the immediate 48-h period following a total abdominal hysterectomy. Crow et al.[2] examined the effect of OMT on patients who developed a bowel ileus postoperatively. A non-obstructive, paralytic, bowel ileus occurs when the normal propulsitile activity of the gastrointestinal system is disrupted by autonomic and inflammatory processes. Their study found that those patients who received OMT had a mean length of stay (LOS) of 2.8 days less than those who did not receive OMT. Baltazar et al.[3] investigated the use of OMT after major abdominal surgery and found OMT reduced time to flatus and decreased LOS. Wieting et al.[4] investigated the use of OMT after coronary artery bypass graft (CABG) surgery and found patients receiving OMT had more rapid functional improvements and a decrease in LOS compared to control patients.

A thoracotomy is a surgical procedure that involves making an incision into the pleural space of the chest. This procedure may be used to remove all or part of a lung or remove fluid or infection. For pulmonary resections, a posterolateral thoracotomy is commonly used. For this procedure, the patient is placed in the lateral recumbent position with the upper arm flexed forward to rotate the scapula away from the incision, and the surrounding musculoskeletal structures are held in an altered position for several hours. This approach transects major muscles and with the subsequent spreading of the ribs disrupts normal mechanical structure and function of the rib cage, potentially leading to postthoracotomy pain syndrome.[5] Therefore, because of the somatic dysfunction caused by the procedure, OMT may benefit the postthoracotomy patient.

Hirayama et al.[6] examined the effects of manual therapy on postoperative pain after pulmonary resection by posterolateral thoracotomy. Patients were an average of 17 days postoperative when they received manual therapy, and they received one treatment each week for three weeks. Pain severity was measured using a visual analog scale, where the scale was set at ten before the first treatment. After three sessions, all patients showed a decrease in pain from ten to an average of 1.9 (range, 1.3—2.6).[6] O-Yurvati et al.[7] examined the effects of OMT immediately following sternotomy for CABG surgery. Pre-OMT versus post-OMT measurements showed significant hemodynamic benefits with improved cardiac function and perfusion, suggesting that OMT improved fluid homeostasis.[7]

While the mean LOS for posterolateral thoracotomy surgery in general is unknown, in a study by Paul et al.,[8] 1281 patients with lung cancer who had lobectomy by thoracotomy had an average LOS of six days. In another study, Scott et al.[9] found the average LOS to be seven days in 686 patients with lung cancer who had lobectomy by thoracotomy. To our knowledge, no studies have investigated the effect of OMT on LOS in patients who have undergone lung resection via posterolateral postthoracotomy. Therefore, the current exploratory study retrospectively evaluated the effect of OMT on the LOS of hospitalized posterolateral postthoracotomy patients compared with patients who did not receive OMT. We hypothesized that OMT would decrease the LOS in hospitalized patients who had undergone a lung resection via posterolateral postthoracotomy compared with patients who did not receive OMT.

Materials and methods

The current retrospective study was reviewed and approved by the local institutional review board. Electronic billing records from a rural hospital were searched from 1998 through 2011 for patients receiving thoracotomies with lung resections as defined by the International Classification of Diseases Ninth Revision[10] codes listed in Table 1. Men and women of all ages and race and ethnicity groups were included in the current study. Potential records were excluded from the current study if the patient had a thoracotomy without lung resection, a postmortem thoracotomy with lung resection, a thoracoscopy with lung resection, or a video-assisted thoracoscopic surgery with lung resection. Patients who were transferred to another acute care facility during their postsurgical hospital stay or whose hospital medical records were inaccessible were also excluded from the current study. When only a portion of the hospital medical record was available, useable data from those patients was limited to the accessible information. At the rural hospital of the current study, only one surgeon performs open lung resections, and he uses the posterolateral thoracotomy approach.

Table 1 International classification of diseases ninth revision (ICD-9) codes used in the current study to identify patients who received thoracotomies with lung resection.

ICD-9 code	Description
32	Excision of lung and bronchus
32.0	Local excision or destruction of lesion or tissue of bronchus
32.1	Other excision of bronchus
32.2	Local excision or destruction of lesion or tissue of lung
32.3	Segmental resection of lung
32.4	Lobectomy of lung
32.5	Pneumonectomy
32.6	Radical dissection of thoracic structures
32.9	Other excision of lung

Medical records were reviewed for patient age, sex, smoking history, data of admission, date of discharge, thoracotomy surgery data, total number of specialty consultations, osteopathic manipulative medicine (OMM) consultation data, and discharge diagnoses and location. Specific notations were made of those patients who had a discharge diagnosis of postoperative ileus. The LOS was determined from the admission date from the history and physical report and the discharge date from the discharge report.

The thoracotomy surgery data included the following information: length of time from admission to thoracotomy surgery, indications for surgery, length of surgery, total number and type of additional procedures performed during the thoracotomy surgery, and intensive care unit (ICU) utilization.

The OMM consultation data included the following information: date of initial OMM consultation, total number of visits from the OMM consultation service, postoperative status at the time of the initial OMM consultation, the location of the initial OMM consultation, ventilator use prior to and at the time of the initial OMM consultation, and date of discharge from the OMM consultation service. Additional data included the OMM consultation chief complaint and final assessments, participation in the consultation by resident physicians or medical students, regions of somatic dysfunction documented and osteopathic manipulative techniques used.

Analysis

The data were analyzed using SAS statistical software (version 9.3, SAS Institute, Inc.). All available data were used in the analyses. Because most of the continuous variables were not normally distributed, nonparametric statistical methods were used. Mann—Whitney tests were used to compare those who received OMT and those who did not for the following variables: age, LOS for all thoracotomy patients and excluding patients with a discharge diagnosis of postoperative ileus, length of time from admission to thoracotomy surgery, length of thoracotomy surgery, total number of procedures performed during the thoracotomy surgery, and total number of consultations ordered excluding OMM. Fisher exact tests were used to compare the groups on sex, smoking history, indications for thoracotomy surgery, types of procedures performed during the thoracotomy surgery, discharge location, and admission directly to the ICU following the surgical procedure. A Mann–Whitney test was also used to test for an association of LOS with smoking history and with the types of procedures performed during the thoracotomy surgery. For patients who received OMT, descriptive statistics (frequencies and percentages or means and standard deviations [SD]) were used to summarize the data for the following variables: time from thoracotomy surgery to the OMM consultation, number of visits from the OMM consultation service, whether or not the patient was postoperative at the time of the OMM consultation, location at the time of the OMM consultation, ventilator use prior to the OMM consultation, ventilator use at the time of the OMM consultation, whether or not the patient was discharged from the OMM service before being discharged from the hospital, OMM consultation chief complaint, final OMM assessment, resident or medical student participation in the OMM consultation, regions of somatic dysfunction noted, and osteopathic manipulative techniques used. $P \leq .05$ were considered statistically significant. Due to the exploratory nature of the current study, no adjustment for multiple comparisons was made to the significance level to avoid inflating the type II error rate.

Table 2 Demographic characteristics of patients receiving osteopathic manipulative treatment (OMT) or No OMT following thoracotomy with lung resection.

Study variable	Total sample ($N = 38$)	OMT ($n = 23$)	No OMT ($n = 15$)	*P* value
Demographics				
Age, *y*, mean (SD)	59 (19)	62 (20)	54 (16)	.09
Sex, *n* (%)				.74
Male	21 (55%)	12 (57%)	9 (43%)	
Female	17 (45%)	11 (65%)	6 (35%)	
Smoking history, *n* (%)				.84
Current	16 (42%)	9 (56%)	7 (44%)	
Former	12 (32%)	7 (58%)	5 (42%)	
Never	10 (26%)	7 (70%)	3 (30%)	

Results

Thirty-eight patients (21 [55%] males and 17 [45%] females) received a thoracotomy with lung resection between 1998 and 2011 (Table 2). Twenty-three patients (61%) received OMT during their acute care hospital admission, and 15 patients (39%) did not. All patients who received OMT during their hospitalization did so via an OMM specialty consultation. There were no significant differences in patient demographics between those patients who had OMT and those who did not (all $P > .09$).

There was no significant difference in LOS between those who had OMT (mean [SD], 11.0 [6.8] days) and those who did not have OMT (10.4 [5.5] days, $P = .90$) (Table 3). Smoking history was not related to LOS ($P = .77$). The mean (SD) LOS was 12.4 (7.8) days for patients who were current smokers, 9.8 (4.9) days for patients who were former smokers, and 9.3 (4.5) days for patients who had never smoked.

There were no significant differences in the length of time from admission to thoracotomy surgery, indications for thoracotomy surgery, length of thoracotomy surgery, and total number and types of procedures performed between those patients who had OMT and those who did not (all $P \geq .29$) (Table 3). Some patients had more than one type of thoracotomy procedure performed. Those patients who had two types of thoracotomy procedures had a longer LOS (mean [SD], 15.1 [6.9] days) than those who only had one procedure (8.8 [4.9] days, $P = .002$). Eight of the 12 patients (67%) who had two procedures received an OMT consultation. Thirty-two patients (84%) were admitted directly to the ICU following their surgical procedure(s). Twenty-two of the 23 patients who received OMT were admitted directly to the ICU (96%) compared with 10 of the 15 patients who did not receive OMT (67%, $P = .03$).

The effect of the type of thoracotomy procedure performed on LOS is outlined in Table 4. The most common surgical procedure was a wedge resection of the lung (26 [68%]). Fifteen of the 26 patients (58%) who had a wedge resection performed had an OMM consultation. Having a decortication performed, which involves the removal of a restrictive, fibrous capsule that has formed in the pleural space, increased LOS by a mean of 6.4 days ($P = .005$). Six of the 9 patients (67%) who had a decortication performed had an OMM consultation.

There was no significant difference in total number of consultations ordered excluding OMM between those patients who had OMT and those who did not ($P = .77$) (Table 3). There was no significant difference for discharge location between those patients who received OMT and those who did not ($P = .89$) (Table 3). Five of the 23 patients (22%) who received OMT and none of the patients who did not receive OMT had a discharge diagnosis of postoperative ileus ($P = .14$). Excluding patients

Table 3 Comparisons of patients receiving osteopathic manipulative treatment (OMT) or No OMT following thoracotomy with lung resection.

Study variable	Total sample ($N = 38$)	OMT ($n = 23$)	No OMT ($n = 15$)	*P* value
Length of stay, *d*, mean (SD)	10.8 (6.2)	11.0 (6.8)	10.4 (5.5)	.90
Range, *d*	3–29	5–29	3–22	
Thoracotomy surgery				
Time from admission, *d*, mean (SD)	1.8 (3.0)	1.6 (3.1)	2.1 (3.0)	.29
Indications for surgery, *n* (%)				.92
Cancer	7 (18)	5 (22)	2 (13)	
Hemoptysis	1 (3)	1 (4)	0	
Pneumothorax	5 (13)	3 (13)	2 (13)	
Emphysematous bleb	1 (3)	0	1 (7)	
Empyema	9 (24)	5 (22)	4 (27)	
Lung mass	15 (39)	9 (39)	6 (40)	
Length of surgery, *h*, mean (SD)	3.4 (1.1)	3.5 (1.1)	3.3 (1.2)	.68
No. procedures performed, mean (SD)	1.3 (.5)	1.3 (.5)	1.3 (.5)	.60
Types of procedures performed, *n* (%)				
Wedge resection of lung	26 (68)	15 (65)	11 (73)	.73
Lobectomy of lung	12 (32)	8 (35)	4 (27)	.73
Decortication of lung	9 (24)	6 (26)	3 (20)	>.99
Total pneumonectomy	2 (5)	1 (4)	1 (7)	>.99
Partial pneumonectomy	1 (3)	1 (4)	0	>.99
Admission directly to ICU following procedure, *n* (%)	32 (84)	22 (96)	10 (67)	.03[a]
No. of consults ordered (excluding OMM), mean (SD)	1.2 (.6)	1.1 (.6)	1.2 (.6)	.77
Discharge location, *n* (%)				.89
Home	30 (79)	17 (74)	13 (87)	
Rehabilitation unit	1 (3)	1 (4)	0	
Skilled nursing facility	5 (13)	3 (13)	2 (13)	
Death	2 (5)	2 (9)	0	
Discharge diagnosis of postoperative ileus	5 (13)	5 (22)	0	.14

Abbreviations: ICU, intensive care unit; OMM, osteopathic manipulative medicine; SD, standard deviation.
[a] Fisher exact test. Statistically significant finding.

with a diagnosis of postoperative ileus, there was no significant difference in LOS between those who had OMT (mean [SD], 12.2 [7.3] days) and those who did not have OMT (10.4 [5.5] days, $P = .62$).

The time from surgery to the OMM consultation was a mean (SD) of 0.6 (4.0) days (range, 6 days before the surgery to 16 days after the surgery). Patients received a visit from the OMM consultation

Table 4 Effect of specific surgical procedure on length of stay (LOS) in posterolateral postthoracotomy patients.

Surgical procedure	LOS, *d*, mean (SD), (range)		*P* value[a]
	Patients having specific surgical procedure	Patients not having specific surgical procedure	
Wedge resection of lung ($n = 26$)	11.0 (6.7), (3–29)	10.3 (5.5), (5–22)	.87
Lobectomy of lung ($n = 12$)	11.6 (6.6), (5–29)	10.4 (6.2), (3–26)	.49
Decortication of lung ($n = 9$)	15.7 (6.5), (7–26)	9.3 (5.4), (3–29)	.005[c]
Total pneumonectomy ($n = 2$)	9.0 (2.8), (7–11)	10.9 (6.4), (3–29)	.92
Partial pneumonectomy ($n = 1$)	7.0 (NA),[b] (NA)	10.9 (6.3), (3–29)	.55

Abbreviations: NA, not applicable; SD, standard deviation.
[a] *P* value from Mann–Whitney test of those patients who had the specified procedure compared with those patients in the study group who did not have that procedure on LOS.
[b] Standard deviation and range not available because only 1 patient had a partial pneumonectomy.
[c] Statistically significant finding.

service a mean (SD) of 7.2 (4.9) separate days (range, 2–21 days). Of the 23 patients receiving an OMM consultation, 22 patients (96%) were postoperative at the time of the OMM consultation. Nineteen patients (83%) were located in the ICU at the time of the OMM consultation. Fifteen of the 23 patients who had an OMM consultation (65%) were not able to come off the ventilator immediately after the thoracotomy procedure, and 5 of these 15 patients (33%) were on the ventilator at the time of the OMM consultation. Eight of the 23 patients (35%) who had an OMM consultation were discharged from the OMM consultation service before being discharged from the hospital.

There were five chief complaints noted on the initial OMM consultation report: chest/rib pain (16 [70%]), homeostatic support (3 [13%]), thoracic pain (2 [9%]), lower respiratory infection (1 [4%]), and lumbar pain (1 [4%]). There were four final consultation assessments noted on the initial OMM reports or subsequent OMM progress notes: chest/rib pain (19 [83%]), thoracic pain (2 [9%]), lower respiratory infection (1 [4%]), and lumbar pain (1 [4%]). Nineteen OMM consultations (83%) involved resident or medical student participation. The regions of somatic dysfunction treated with OMT are outlined in Table 5. All patients who received OMT were treated for somatic dysfunction of the cervical, thoracic, and rib regions. The OMT techniques used are outlined in Table 6. The most commonly used types of OMT techniques were myofascial release (23 patients [100%]), balanced ligamentous tension (20 [87%]), muscle energy (16 [70%]), and rib raising (16 [70%]).

Table 6 Osteopathic manipulative techniques used in posterolateral postthoracotomy patients ($N = 23$).

Techniques	No. of patients (%)
Myofascial release	23 (100)
Balanced ligamentous tension	20 (87)
Muscle energy	16 (70)
Rib raising	16 (70)
Articulatory	14 (61)
Cranial	14 (61)
Inhibition	14 (61)
Soft tissue	13 (57)
Other osteopathic manipulative techniques	9 (39)
Visceral	8 (35)
Still technique	7 (30)
Facilitated positional release	6 (26)
Neurofascial release	6 (26)
Counterstrain	4 (17)
Lymphatic	4 (17)
Integrated neuromusculoskeletal release	2 (9)
Unspecified	2 (9)
High velocity low amplitude	1 (4)

Discussion

In the current study, OMT did not significantly affect the LOS in patients who received a lung resection via posterolateral postthoracotomy. However, neither smoking history nor postoperative ileus increased LOS in the current study even though both conditions have been found to increase postoperative LOS in larger studies. A prospective study by Barrera et al.[11] of 300 patients undergoing lung resection for lung cancer found that the overall pulmonary complication rate was higher ($P = .03$) and the LOS greater (mean, 9 vs 6 days; $P < .05$) for ongoing smokers compared with nonsmokers. In the current study, all patients with a discharge diagnosis of postoperative ileus, which is known to increase LOS,[12] had received OMT. A large national database study found that postoperative patients coded with postoperative ileus showed a mean increase in LOS of six days compared with patients without postoperative ileus.[12] The findings from these larger studies suggest the current study was likely insufficiently powered to demonstrate a significant difference in LOS.

In the current study, the severity of illness appeared to be greater for those who received OMT than those who did not. A majority of those receiving OMT were admitted directly to the ICU, which also suggests a greater severity of illness. Additionally, 67% of the patients who received OMT had two surgical procedures, which was associated

Table 5 Regions of somatic dysfunction treated in posterolateral postthoracotomy patients ($N = 23$).

Body region	No. of patients (%)
Cervical	23 (100)
Thoracic	23 (100)
Ribs	23 (100)
Head	17 (74)
Abdomen	17 (74)
Lumbar	13 (57)
Sacrum	10 (43)
Upper extremity	10 (43)
Pelvis	7 (30)
Lower extremity	5 (22)

with a statistically significant increase in LOS by 6.3 days. Further, 67% of those patients having a decortication received OMT, which was associated with a statistically significant increase in LOS by 6.4 days.

In the current study, OMM consultations were requested by either the thoracic surgeon or one of the other consulting physicians. OMT was initiated six days before surgery to 16 days after surgery. Because OMT was initiated up to 16 days following the surgical procedure in some cases, our results may have been different if the OMM consultation service had been consulted immediately after surgery or before surgery for all patients. Studies assessing the effect of OMT on postoperative outcomes have used different timing of the OMT. Goldstein et al.[1] initiated OMT approximately four hours after the patient was returned to their room following a total abdominal hysterectomy. O-Yurvati et al.[7] initiated OMT within two hours following CABG surgery. In a retrospective study conducted by Crow et al.,[2] OMT consultations were typically delayed 3—4 days after abdominal surgery to allow bowel function to normalize without intervention. In studies looking at the effect of OMT on pneumonia patients,[13—15] OMT was initiated with the first 24 h of admission or within the first 24 h of making the pneumonia diagnosis. Future prospective postthoracotomy studies should initiate OMT within a specified time to decrease the impact of initiating OMT at different times. This variability may have influenced results of the current study.

Because of the retrospective nature of the current study, there was no standardization of body regions treated or OMT techniques used. Therefore, no conclusions can be made about the efficacy of any particular osteopathic technique. For example, a lymphatic technique was only documented in 4 patients who received OMT even though lymphatic techniques have been shown to be beneficial in the inpatient setting.[7,13,14] However, most lymphatic techniques such as thoracic inlet release were likely documented as myofascial release, leaving only techniques such as effleurage and lymphatic pumps to be documented as lymphatic. In studies looking at the effect of OMT on pneumonia patients,[13—15] a specific protocol was used. For the Multicenter Osteopathic Pneumonia Study in the Elderly (MOPSE),[13,14] the protocol included soft tissue to the thoracic and cervical spine, rib raising, doming the diaphragm, suboccipital inhibition, myofascial release to the thoracic inlet, thoracic lymphatic pump with activation, and the pedal lymphatic pump. The goal of this protocol was to improve the function of the musculoskeletal, autonomic, and lymphatic systems.[13] Future prospective studies assessing OMT in the postthoracotomy patient should include a protocol of techniques to target musculoskeletal, lymphatic, and autonomic dysfunction.

The current study did not compare pain medication usage between those patients who received OMT and those who did not, and it did not follow the patients as outpatients to determine the effect of postoperative OMT on postthoracotomy pain syndrome, which occurs in more than 50% of patients.[16] Postthoracotomy pain syndrome is defined as pain that recurs or persists along the thoracotomy incision for at least 2 months following the surgical procedure.[17] The posterolateral thoracotomy requires transection of several different muscles, including the latissimus dorsi, serratus anterior, and internal and external intercostal muscles. The incision is typically made above either rib 5 or rib 6, and then a rib spreader is used that may cause additional dysfunction to the adjacent articular and myofascial structures of the ribs. Shoulder movement worsens the pain in 24% of postthoracotomy pain syndrome patients,[18] and frozen shoulder can result from disuse.[19] In a study by Hamada et al.,[20] trigger points were found adjacent to the wound in 44% of patients with postthoracotomy pain syndrome and within the scapular region in 67% of patients. Future prospective studies should specifically look at the effects of the posterolateral thoracotomy surgery on regional somatic dysfunction and on how OMT can be implemented to improve the function of the musculoskeletal, autonomic, and lymphatic systems.

The limitations of the current study include low patient volume, differences in illness severity between the groups, lack of consistency in initiating OMT postoperatively, and lack of consistency with the osteopathic techniques used and body regions treated with OMT. Further, the reasons for the thoracotomy, the procedures performed, and comorbidities of the patients could have affected the LOS results. For example, the majority of those patients undergoing a decortication received OMT, yet the mean LOS of the OMT group was the same as those who did not receive OMT. Because the surgical procedures in the current study were performed by one surgeon, the use of more aggressive procedures, or a more critically ill patient may have prompted his request for an OMM consultation. A larger sample size may have yielded significant differences between groups and the inclusion of patients from more than one surgeon would increase the generalizability of the results. As with all retrospective studies, unknown variables and biases could be present that we were unable to account for.

Many of the limitations of the current study could be addressed in future studies. Randomized controlled trails with a larger patient volume would be the most appropriate to assess the effect of administering OMT immediately following surgery or before surgery. Objective measurements of preoperative and postoperative pulmonary function could be measured to compare those who received OMT and those who did not. A standardized OMT protocol could be developed for future studies on postthoracotomy patients that would decrease variability of the OMT received by the patients. Also, the effect of OMT on the incidence of postthoracotomy pain syndrome, use of antibiotics, and narcotic usage could be studied. Considering the musculoskeletal and fascial dysfunction that may be contributing to postthoracotomy pain syndrome, the application of OMT in postthoracotomy patients may reduce pain.

Conclusion

The current study found no significant difference in LOS for those patients who received OMT and those who did not. However, the patients in the current study who received OMT may have had a greater severity of illness as evidenced by increased ICU utilization than those who did not receive OMT. Therefore, the equivalent LOS of the 2 groups, despite the disparity of illness severity, may have been a result of the OMT or other factors that we were unable to control for with the current design. Future studies should be performed at locations that have a higher procedure volume to evaluate more patients and stratify for illness severity. Such studies could also follow patients in the outpatient period to assess long-term pain outcomes. Results from such studies may elucidate the effect of OMT on LOS and the incidence of postthoracotomy pain syndrome.

Author contribution statement

Kent J. Blanke, DO conceived the idea for the study and provided critical revision.

Regina K Fleming, DO, Karen T. Snider, DO, and Jane C. Johnson, MA participated in study design, data acquisition, data analysis and interpretation, drafting of the manuscript, and critical revision.

All authors edited and approved the final version of the manuscript.

Conflict of interest

None declared.

Ethical approval

Ethics approval was provided by AT Still University — Kirksville College of Osteopathic Medicine Institutional Review Board.

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