Short-Term Hematologic and Hemodynamic Effects of Osteopathic Lymphatic Techniques: A Pilot Crossover Trial

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Context: Research into the physiologic effects of osteopathic lymphatic techniques has been somewhat limited.

Objective: To assess the short-term hematologic and hemodynamic effects of a comprehensive lymphatic treatment protocol.

Methods: Randomized crossover design that included 10-minute lymphatic treatment and rest (control) protocols delivered 1 week apart for a small pilot group of healthy men (N=15). At baseline, albumin, hematocrit, hemoglobin, platelet count, total protein, and white blood cell count were measured, as were systolic and diastolic blood pressure. All measures were repeated 20, 50, and 80 minutes after baseline data were gathered.

Results: Significant condition × time interaction effects were observed, indicating a decrease in platelet counts and an increase in diastolic blood pressure after the lymphatic treatment protocol. Statistically significant differences by time were observed in all hematologic measures and in systolic blood pressure. No adverse events or complications from the treatment protocol were observed in this population.

Conclusion: Lymphatic techniques may decrease platelet counts and increase diastolic blood pressure during the first hour after treatment. (ClinicalTrials.gov number NCT 00742989)

Since its inception, osteopathic manipulative medicine has addressed the lymphatic system. The goals of osteopathic lymphatic techniques are to increase lymphatic circulation and improve the clearance of interstitial fluid, protein, and inflammatory agents from the interstitium. Practitioners and researchers expect these techniques to produce beneficial immunologic and mechanical effects.

The lymphatic vessels collect and move about 120 mL of lymph each hour under normal conditions. The flow of lymph depends directly on the rate of lymph formation, intrinsic contraction of the lymphatic vessels controlled by the sympathetic nervous system, and the pressure gradients between the lymphatic trunks and the central veins. Extrinsic forces, such as skeletal muscle contraction, respiration, and mechanical pressure from outside the body also contribute substantially to the rate of flow within this system.

Osteopathic lymphatic techniques are purported to remove restrictions to lymphatic flow through manual treatment of myofascial restrictions and the sympathetic nervous system and to augment externally lymphatic flow through effleurage and lymphatic pumps. Specifically, these manual techniques are hypothesized to use extrinsic compression, activation of lymphatic internal and external stretch reflexes, amplification of respiratory pressure gradients, extrinsic magnification of pressure gradients, and normalization of sympathetic nervous activity to the contractile elements of lymph vessels to affect the movement of lymphatic fluid.

The effects of lymphatic techniques have yet to be fully elucidated. Animal studies have documented increases in flow through the thoracic duct and changes in serologic markers after the use of lymphatic pump techniques.

Preliminary human studies have reported promising data. One such study used a comprehensive lymphatic protocol for elderly patients with pneumonia to decrease hospital stay and antibiotic use. These techniques have also been shown to improve forced vital capacity and forced expiratory volume after abdominal surgery. Perhaps most famously, however, comprehensive lymphatic treatments were reported to decrease mortality rates during the influenza pandemic of 1918.

Studies of the hematologic effects of lymphatic techniques in healthy human subjects report inconsistent changes in blood cell count. An uncontrolled study investigating the effects of a lymphatic treatment protocol on blood cell count showed an increase in leukocytes. An abstract for a controlled study.
also demonstrated an increase in leukocyte counts and in the concentrations of B and T cells after lymphatic pumping. A more recent study\textsuperscript{21} of these techniques used a control cohort retrospectively recruited and found a transient basophilia without lymphocytosis.

The purpose of the present study was to evaluate the short-term effects of a thorough lymphatic treatment protocol developed by Wallace and coinvestigators\textsuperscript{2} and designed to include techniques to influence sympathetic tone, the thoracic inlet, the thoracic diaphragm, and the lymphatics. Hematologic and hemodynamic parameters were observed. A comprehensive lymphatic treatment protocol in a randomized controlled study is unique among the hematologic studies reviewed. The current investigation represents a novel approach to the study of the hematologic and hemodynamic effects of osteopathic lymphatic techniques.

Methods
Healthy men aged between 24 and 30 years were recruited for participation in the present study. All subjects were affiliated with Kansas City (Mo) University of Medicine and Biosciences College of Osteopathic Medicine. Study participation was voluntary. The study was reviewed and approved by the university’s institutional review board. Informed consent was obtained from each subject.

Inclusion criteria for study participation were as follows: sex, male; age, 20–40 years; no history of tobacco use; medical history negative for cancer and liver disease as well as any acute or chronic illness (within 2 weeks of study initiation), including those of the cardiovascular, hematologic, or renal systems.

Women were excluded from this study because of changes in fluid regulation resulting from the menstrual cycle. Subjects engaged in an endurance training program were likewise excluded because of resulting physiologic changes in fluid regulation.

We used a randomized crossover design for the present study. During the first experimental session, subjects were randomly allocated to one of two study groups. Subjects in the first group received the lymphatic treatment protocol during the first session and were asked to rest in a supine position during the second session (control). Subjects in the second study group completed the same two protocols in reverse order. A 1-week washout period separated the two sessions for both study groups. The term “lymphatic treatment” is used in the present study, as defined in the Glossary of Osteopathic Terminology\textsuperscript{22} to indicate the use of techniques intended to optimize the function of the lymphatic system. This phrase does not indicate intent to manage a disease or diagnosed medical condition.

Subjects were instructed not to exercise, not to take medication or supplements, and not to receive osteopathic manipulation, chiropractic manipulation, or massage for 3 days before their two scheduled sessions. They were also instructed not to eat or drink anything for 12 hours before either session.

The total amount of time required of the subjects in this protocol was about 2 hours. For this reason, subjects were invited to bring audiotapes or CD-ROMs to listen to during the protocol. In addition, researchers provided subjects with access to a radio and a small selection of audibooks. Climate control maintained ambient room temperature between 72° and 74°F during study sessions.

On arrival at the study site, subjects were asked to void urine. Weight and height were measured. They were then given instructions to drink water—5 mL of water per kilogram of bodyweight. A venous catheter was inserted into a large antecubital vein on the subject’s right arm or left arm. He was then asked to assume a supine position. This position was maintained for the remainder of the experimental session. A pulse oximeter was placed on a fingertip of the uncatheterized arm. Heart rate was recorded every 10 minutes.

Because dilution of plasma proteins, hemoglobin, and hematocrit approaches stability at 20 minutes after assumption of the supine position—with full stabilization reached by 40 minutes\textsuperscript{23}—our study design incorporated a 35-minute stabilization period before baseline measures were gathered. This stabilization period was intended to minimize time effects on the concentrations of blood constituents\textsuperscript{23–25}

After supine rest for 35 minutes, 8 mL of venous blood was taken for baseline measurement of albumin, hematocrit, hemoglobin, platelet count, total protein, and white blood cell count. Blood pressure was also recorded.

Five minutes after baseline measures were gathered, the lymphatic treatment protocol was initiated—unless subjects were allocated to the control group, in which case they received continued rest in the supine position.

The lymphatic treatment protocol consisted of the following sequence of steps:

- direct myofascial release for the thoracic inlet for 30 seconds
- rib raising on each side of the body for 60 seconds
- thoracic pumping for 60 seconds
- thoracic pump variation of activation\textsuperscript{2} for 30 seconds
- doming of the abdominal diaphragm for 30 seconds
- abdominal pumping for 60 seconds
- pedal pumping for 60 seconds
- a second thoracic pump for 60 seconds
- a second thoracic pump variation of activation for 30 seconds
- direct myofascial release for the thoracic inlet for 30 seconds

Each of the techniques in the lymphatic treatment protocol described by Wallace and colleagues\textsuperscript{2} was provided by the same investigator (W.E.R.) for each subject. Several seconds were required to transition from one technique to the next. The study protocol called for a total of 10 minutes of active treat-
Between sessions.

In addition, a repeated measures ANOVA was performed on subjects’ self-identified racial/ethnic groups were as follows: white, 11; American Indian, 1; and Hispanic, 1.

Age range for enrolled subjects who completed the study was 24-30 years, with a mean (SD) age of 26.5 (1.8) years. Subsequent blood count data for 12 subjects. Of the 15 subjects who completed the protocol, 2 individuals had minor abnormalities in their blood cell count that led to data exclusion. In addition, the complete blood count for 1 subject was not processed by the laboratory. Therefore, our final analysis includes data for albumin, total protein, and hemodynamic measures for 13 subjects but not for the control protocol.

Each repeated measures ANOVA generated three tests:

- **Condition effect**—Examines differences between treatment and control arms (ie, condition) without regard to the time order of data points. The presence of a statistically significant condition effect would imply that the data obtained during treatment differed overall from the data obtained during the control protocol.

- **Time effect**—Examines differences in time-ordered data without regard to condition. The presence of a significant time effect would imply that the mean values for the baseline and 20-, 50-, and 80-minute intervals varied statistically.

- **Condition × time interaction effect**—Examines differences in condition and differences in time-ordered data simultaneously. The presence of a significant condition × time interaction would imply that the values of the outcome measured at a unique combination of condition and time produced values that differed statistically from those observed in other combinations.

In addition, a repeated measures ANOVA was performed on baseline values alone to determine if initial values changed between sessions.

No serious adverse events were reported secondary to the lymphatic treatment protocol or the venipuncture.

Baseline values for hematologic (*Table 1*) and hemodynamic (*Table 2*) measurements did not substantially differ between sessions on any outcomes measured.

There were statistically significant (*P* < .05) time effect increases for all hematologic measures. There was a statistically significant (*P* < .05) time effect decrease by time in systolic blood pressure only.

Analysis showed two statistically significant (*P* < .05) condition × time interaction effects: hemoglobin platelet count decreased and diastolic blood pressure increased posttreatment. Likewise, diastolic blood pressure was higher during the session in which subjects received the lymphatic treatment protocol.

Heart rate showed no statistically significant differences by condition, time, or in condition × time analyses. Heart rate for the control session ranged from 52.58 to 56.5 beats per minute; for the lymphatic treatment session, this range was 52.08 to 56.42 beats per minute.

**Comment**

The present study assessed the effect of a comprehensive lymphatic treatment protocol on physiologic measures in healthy men.

According to our analysis, platelet count and diastolic blood pressure were affected by the lymphatic treatment protocol. Diastolic blood pressure was higher during treatment sessions than during resting control sessions. The statistically significant changes observed may indicate that there is a sympathoexcitatory response to some or all of the lymphatic techniques used.

Our data are consistent with other studies that have reported an increase in diastolic blood pressure with a mobilization technique of the lower cervical spine. The literature also suggests that rib raising causes a short-term sympathoexcitation.

Although platelet counts decreased in posttreatment measures, a change of approximately 6000 platelets is not likely to be of clinical significance. Further studies of platelet count and function after lymphatic treatment may allow additional insight into this observation. The decline in systolic blood pressure observed in subjects participating in the present study is expected as a result of hemodynamic acclimatization in the supine position. The time effects observed for the other parameters measured are less easily explained.

*Table 1* documents consistent elevations in hematocrit, hemoglobin, platelet count, and total protein throughout the 80-minute measurement period—long after the effect of posture-induced hemodilution should have stabilized.

The data also reveal hemoconcentration during the measurement period, which is an unexpected finding. Hemoconcentration typically accompanies dehydration or the assump-
Table 1
Short-Term Effects of Osteopathic Lymphatic Techniques:
Hematologic Variables by Treatment and Time

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment Received</th>
<th>Baseline Measure, Mean (SD)</th>
<th>Postbaseline Measures, Mean (SD)</th>
<th>P Value*</th>
<th>Condition Effect</th>
<th>Time Effect</th>
<th>Condition Time Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20 min</td>
<td>50 min</td>
<td>80 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>■ Albumin, g/dL</td>
<td>N</td>
<td>4.25 (0.21)</td>
<td>4.23 (0.24)</td>
<td>4.26 (0.22)</td>
<td>4.29 (0.25)</td>
<td>...</td>
<td>.041</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>4.17 (0.30)</td>
<td>4.21 (0.27)</td>
<td>4.20 (0.28)</td>
<td>4.26 (0.29)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>■ Hematocrit, %</td>
<td>N</td>
<td>44.58 (2.41)</td>
<td>44.76 (2.33)</td>
<td>45.01 (2.58)</td>
<td>45.18 (2.33)</td>
<td>...</td>
<td>.041</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>44.43 (2.16)</td>
<td>44.68 (2.27)</td>
<td>44.71 (2.24)</td>
<td>45.01 (2.27)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>■ Hemoglobin, g/dL</td>
<td>N</td>
<td>14.45 (0.88)</td>
<td>14.48 (0.86)</td>
<td>14.71 (0.88)</td>
<td>14.74 (0.83)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>14.44 (0.71)</td>
<td>14.50 (0.80)</td>
<td>14.63 (0.86)</td>
<td>14.69 (0.83)</td>
<td>...</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>■ Protein (Total), g/dL</td>
<td>N</td>
<td>6.64 (0.33)</td>
<td>6.70 (0.26)</td>
<td>6.75 (0.27)</td>
<td>6.79 (0.31)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>6.58 (0.35)</td>
<td>6.63 (0.33)</td>
<td>6.67 (0.34)</td>
<td>6.70 (0.32)</td>
<td>...</td>
<td>.002</td>
</tr>
<tr>
<td>■ Platelet Count, (\times 10^{11}/\mu\text{L})</td>
<td>N</td>
<td>192.67 (33.66)</td>
<td>192.17 (36.55)</td>
<td>190.67 (33.04)</td>
<td>193.58 (31.95)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>190.17 (38.29)</td>
<td>192.67 (39.00)</td>
<td>188.83 (36.95)</td>
<td>184.08 (35.45)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>■ White Blood Cell Count, /(\mu\text{L})</td>
<td>N</td>
<td>5650 (1770)</td>
<td>5560 (1770)</td>
<td>5800 (1770)</td>
<td>5920 (1910)</td>
<td>...</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>5540 (1580)</td>
<td>5520 (1410)</td>
<td>5550 (1510)</td>
<td>5750 (1380)</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

* Ellipses (…) indicate that the comparison is not statistically significant.

Table 2
Short-Term Effects of Osteopathic Lymphatic Techniques:
Hemodynamic Variables by Condition and Time

<table>
<thead>
<tr>
<th>Blood Pressure, mm Hg</th>
<th>Treatment Received</th>
<th>Baseline Measure, Mean (SD)</th>
<th>Postbaseline Measures, Mean (SD)</th>
<th>P Value*</th>
<th>Condition Effect</th>
<th>Time Effect</th>
<th>Condition Time Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20 min</td>
<td>50 min</td>
<td>80 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>■ Systolic</td>
<td>N</td>
<td>104.62 (9.39)</td>
<td>102.92 (8.27)</td>
<td>104.00 (12.93)</td>
<td>102.00 (9.06)</td>
<td>...</td>
<td>.029</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>106.33 (8.60)</td>
<td>105.83 (10.28)</td>
<td>105.83 (9.70)</td>
<td>103.83 (10.87)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>■ Diastolic</td>
<td>N</td>
<td>67.83 (8.02)</td>
<td>65.00 (8.44)</td>
<td>66.33 (8.12)</td>
<td>65.33 (8.79)</td>
<td>.037</td>
<td>.047</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>68.17 (9.08)</td>
<td>70.33 (7.07)</td>
<td>69.67 (7.62)</td>
<td>72.83 (7.79)</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

* Ellipses (…) indicate that the comparison is not statistically significant.

These time effects may have been the result of random deviations or Type I error. However, because all directly measured values deviated in the same direction, these effects are less likely to have occurred by chance. They may also have resulted from the physiology of the population studied, especially because the low resting heart rate recorded (low to mid 50s) indicates an uncommon degree of cardiovascular fitness among our study subjects. Furthermore, any response to positional changes among these subjects would have been accentuated in the statistical analysis as a result of the study’s crossover design.

Previous studies4,21 on the effects of lymphatic pump have yielded inconsistent results on blood cell counts and did not report hemodynamic measurements. The present study did not find posttreatment leukocytosis4 or basophilia.21 Study protocols and designs differed considerably, however, so the datasets are not directly comparable.

Unlike the other hematologic and immunologic studies...
reviewed in the current article,2,4,8,10,21 the lymphatic treatment protocol we used included multiple manual interventions thought to act on the lymphatic system.2 It is possible that the effects of the different techniques are additive or synergistic. Because the present study was a pilot investigation, we decided to increase the chances of demonstrating an effect by using a comprehensive lymphatic treatment protocol. A similar comprehensive lymphatic treatment protocol was used in another clinical study.9 The current study used a randomized crossover design that allowed subjects to act as their own controls and increased the statistical power of the data.

Improvements to the design used in the present study could include more comprehensive blinding procedures for data collectors. Recording and comparing somatic dysfunction in subjects would also add valuable information to future research efforts. A longer supine rest period for hemodynamic stabilization or a repetition of the study with a larger sample size may also prove worthwhile to researchers who wish to investigate the unexpected time effects we observed. Finally, it may also be helpful to investigate physiologic effects of these treatments in subjects with medical conditions that have been clinically responsive to lymphatic treatments (eg, influenza,19 pneumonia3,9)—once safety considerations have been fully addressed.

The results of the present study reflect the response of a healthy volunteer population to a particular lymphatic treatment protocol. However, our results are not intended to indicate that a clinically important change occurred—nor are they meant to imply that these results apply to a patient population. Our results demonstrate the basic safety of the techniques used and the feasibility of the study design presented. In addition, we present interesting physiologic effects that we believe merit the attention of future research efforts.

Conclusion
We investigated the effects of a lymphatic treatment protocol on healthy young men using a randomized crossover design with a resting control component. There were no adverse events or complications from the techniques used; the lymphatic treatment protocol appears safe and harmless for the healthy volunteer population studied in this investigation.

Our findings document a decrease in platelet count and an increase in diastolic blood pressure. Measures of total protein and white blood cell count showed an increase during the treatment arm for both study groups. Additional research may expand on these data to provide a more comprehensive understanding of the physiologic effects of lymphatic techniques on healthy subjects and on patient populations.

Acknowledgments
We thank Sara Holzbauer de Castellanos, DO, MBA, for her help in the submission of our initial research proposal to the Kansas City (Mo) University of Medicine and Biosciences College of Osteopathic Medicine.

References
7. Lane MA. On increasing the antibody content of the serum by manipulation of the spleen. J Osteopath. 1920;27:361-344.
I asked of my own reason if there was not a cloud of water in the human body that could be caused to drop its dews, put out the fires of fever, and save the forests of life that were being burned every fall season.

Andrew Taylor Still, MD, DO
“The Wisdom of Nature” from Philosophy of Osteopathy (1899)