Lymphology 44 (2011) 13-20

IMPACT OF MANUAL LYMPHATIC DRAINAGE ON HEMODYNAMIC PARAMETERS IN PATIENTS WITH HEART FAILURE AND LOWER LIMB EDEMA

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ABSTRACT

Manual lymphatic drainage (MLD), intermittent sequential pneumatic therapy (ISPT), multilayered bandages (MLB), and compression garments are main techniques in conservative treatment of peripheral lymphedema. Since 1990, it has been thought that ISPT applied to both lower limbs simultaneously should not be used for patients with heart failure because right atrial, pulmonary arterial, and pulmonary wedge pressures may increase to a critical point. In 2005, these same results were observed in patients with heart failure wearing MLB. For these reasons, MLB and ISPT have been contraindicated during lymphedema treatment in cardiac patients. The aim of this study was to determine if we may continue the treatment of lower limb lymphedema using MLD in patients with heart failure. We evaluated hemodynamic parameters using echography during MLD in patients with cardiac disease and obtained circumferential measurements of the edematous limb before and after treatment. MLD treatment significantly decreased the limbs as expected. The heart rate also decreased following MLD in contrast with all other hemodynamic parameters which were not affected by MLD. The findings suggest that there is no contraindication to use MLD in patients with heart failure and lower limb edema.

Keywords: manual lymphatic drainage, heart failure, hemodynamic effects

Manual lymphatic drainage (MLD), intermittent sequential pneumatic therapy (ISPT), multilayered bandages (MLB), and compression garments are main conservative treatment techniques according to the International Society of Lymphology (1). MLD objectives are to improve the lymphatic function (2) and also venous circulation. However, the effect on the venous circulation has not been accurately quantified. We do know that patients suffering from lower extremity lymphedema can experience worsening of their edema when complicated by congestive heart failure. Therefore, the question is: can we still treat those patients with MLD? We do know the effects of ISPT and MLB on the hemodynamic and cardiopulmonary parameters and ISPT and MLB are contraindicated in congestive heart failure (3-5). The objective of this study was to determine the effects of MLD on the hemodynamic and cardiopulmonary parameters in patients with heart disease and associated limb edema.

MATERIAL AND METHODS

Subjects and Protocol

We report studies on 9 patients (3 men and 6 women aged 56 to 82, mean=72) hospitalized in the Cardiology Unit with class III or IV heart failure according to the New York Heart Association. This classification determines the type of heart failure based on symptoms occurring during physical activity. Class III corresponds to discomfort during moderate effort and class IV corresponds to discomfort felt during the slightest effort or at rest. Subjects were in a stable steady-state on maintenance treatment and consented to the study. The protocol was approved by the Hospital Ethical Committee. Subjects have lower limb edema localized at the leg and foot. Subjects with unstable heart conditions, psychiatric disorders, or dementia were excluded.

Patients were placed supine during experiments with a cushion at the heel and proximal aspect of the thigh. MLD was performed on the lower limb according to "Leduc's Technique" consisting initially with application of the inciting technique at the inguinal region followed by its extension down the thigh until the edematous region was reached. The resorption technique was then applied to the edema, and subsequently MLD manipulation was performed in reverse direction with the inciting technique up to the groin. MLD was applied for a total of 15 minutes with the resorption technique being performed during the majority of the time.

Hemodynamic parameters were measured with duplex on the left and right side of the heart according to the schedule outlined in *Table 1* with each patient measured at control and experimental times T1 (after 5 minutes of MLD) and T2 (after completion of MLD). Estimation of left and right ventricular filling pressures usually requires invasive placement of a pulmonary artery catheter but noninvasive estimation by echocardiography is an accurate and recognized method of ventricular filling pressure assessment. In order to estimate hemodynamic effects of MLD, combined echographic measurements were recorded and compared at the different stages of the MLD. The electrocardiogram was used also to monitor heart rate and as a point of reference for Doppler measurements.

Parameters Measured with Duplex on the Left Side of the Heart at the Level of the Mitral Valve

Using E and A wave measurements at the mitral level, we analyzed the diastolic function of the left ventricle. During diastole, the curve of the transmitral blood flow is positive and biphasic. The E wave corresponds to the blood flow entering into the left ventricle at the mitral valve during diastole. The A wave corresponds to the blood flow at the mitral valve in the left ventricle after atrial contraction. The E' wave indicates the velocity of the displacement of the left ventricle wall at the level of the mitral valve. These different parameters estimate the left ventricle diastolic pressure (6,7). The ratio E/A and E/E' (7,8) improves the understanding of the pressure development in the left ventricle and confirms the severity of the cardiac disease. The ratio dP/dT (dP = systolic gradient pressure between left ventricle and left atrium for dT determined) obtained at the level of the mitral valve corresponds to the slope of the curve analyzing the mitral regurgitation during the systole. This observation estimates the velocity of the mitral regurgitation and the systolic pressure in the left ventricle (9,10).

Parameter at the Level of the Aortic Valve

The aortic blood flow provides information about the cardiac flow (11).

Parameter at the level of the ventricle

The shortening fraction (11) evaluates the global systolic left ventricular function.

TABLE 1
Experimental Outline and Timing

Subject Conditions	Timing of Measurements
10 minutes at rest after subject in supine	T0 Baseline measurements
15 minutes MLD	T1 Measurements after 5 minutes MLD
	T2 Measurements after 15 minutes MLD

Parameters Measured with Duplex on the Right Side of the Heart at the Level of the Tricuspid Valve

The maximum tricuspid regurgitation velocity correlates with the systolic arterial pulmonary pressure (12,13). The E and A waves and the ratio E/A, according to the same principle were used at the mitral level to evaluate diastolic right ventricle pressure. The E' wave indicates velocity of the displacement of the right ventricle wall at the level of the tricuspid valve. This parameter and the ratio E/E' estimate the right ventricle diastolic pressure.

Parameters at the Level of the Inferior Vena Cava (IVC)

The variation of the diameter of the inferior vena cava (IVC) during the respiratory cycle indicates the level of the right atrial pressure (14). Expiratory and inspiratory IVC diameters and percent collapse (caval index) was measured within 2 cm of right atrium. A caval index greater than or equal to 50% indicates a right atrial pressure less than 10 mm Hg. A caval index less than 50% indicates a right atrial pressure greater than or equal to 10 mm Hg (15).

Measurement of the Lower Limbs

Measurements of the limbs at the level of the edema were performed by classical manual methods before and after treatment. For the circumference measurements, the reference was the medial malleolus where a horizontal line was drawn as a "tattoo." From this tattoo, three horizontal reference lines were drawn at 10cm, 20cm, and 30cm up the leg and these points were maintained throughout the experiment. Measurements were obtained at these four fixed lines with each measurement repeated three times by the same investigator (a physical therapist). The mean value of the four measurements was calculated for comparisons.

Statistical Analysis

Data were collected at time points T0, T1, and T2. The initial values for the various measures were not homogeneous, and therefore we expressed T1 and T2 values as percentage of the baseline with T0 considered as 100%. Analysis of the variance (ANOVA) was used to evaluate the effect of MLD. When appropriate, Tukey test was used for multiple comparison testing of the mean values. Statistical significance was defined as $p \leq 0.05$.

RESULTS

Baseline echographic parameters were obtained on the nine subjects and are shown in *Table 2*. The subjects have left ventricular dysfunction with dP/dT ratio of less than 800 mm Hg/sec and mitral E/A ratio greater than 2 which is in accordance with high left ventricular diastolic pressure. Their tricuspid

TABLE 2
Echographic Baseline Parameters
n=9 (mean ± SD)

Left ventricular ejection fraction (%)	25.43 ± 10.03
Mitral E wave (m/s)	0.83 ± 0.10
Mitral A wave (m/s)	0.50 ± 0.23
Mitral E/A ratio	2.03 ± 1.02
Mitral E' wave (m/s)	0.13 ± 0.04
Mitral E/E' ratio	7.44 ± 3.45
Ratio dP/dT	629.4 ± 188.9
Systolic pulmonary pressure (mmHg)	25.92 ± 9.85
Tricuspid E wave (m/s)	0.64 ± 0.15
Tricuspid A wave (m/s)	0.56 ± 0.29
Tricuspid E/A ratio	1.35 ± 0.62
Tricuspid E' wave (m/s)	0.12 ± 0.05
Tricuspid E/E' ratio	5.65 ± 1.58

TABLE 3
Experimental Parameters Expressed as Percentage Compared to Baseline (=100%) at times T1 and T2 (Mean ± SD)

Parameter (mean in %)	T1	T2	P-value (ANOVA)
Mitral E wave	98 ± 12	97 ± 14	0.81
Mitral A wave	104 ± 41	98 ± 22	0.91
Mitral E/A ratio	104 ± 32	102 ± 26	0.92
Mitral E' wave	93 ± 25	87 ± 30	0.28
Mitral E/E' ratio	107 ± 32	118 ± 36	0.31
Ratio dP/dT	101 ± 19	113 ± 22	0.16
VTI aortic	116 ± 37	106 ± 26	0.27
Cardiac rhythm	104 ± 7	87 ± 34	0.02
Equival. cardiac flow	115 ± 26	107 ± 24	0.22
max velocity tricuspid insufficiency	94 ± 7	99 ± 28	0.73
Tricuspid E wave	101 ± 21	87 ± 28	0.19
Tricuspid A wave	96 ± 20	92 ± 35	0.72
Tricuspid E/A ratio	109 ± 26	102 ± 34	0.69
Tricuspid E' wave	107 ± 21	109 ± 39	0.68
Tricuspid E/E' ratio	98 ± 24	90 ± 31	0.57
max Ø Inf Vena Cava – min Ø Inf Vena Cava	110 ± 67	164 ± 172	0.70
	After MLD		
Mean circumference of the leg		98 ± 0.83	0.0004

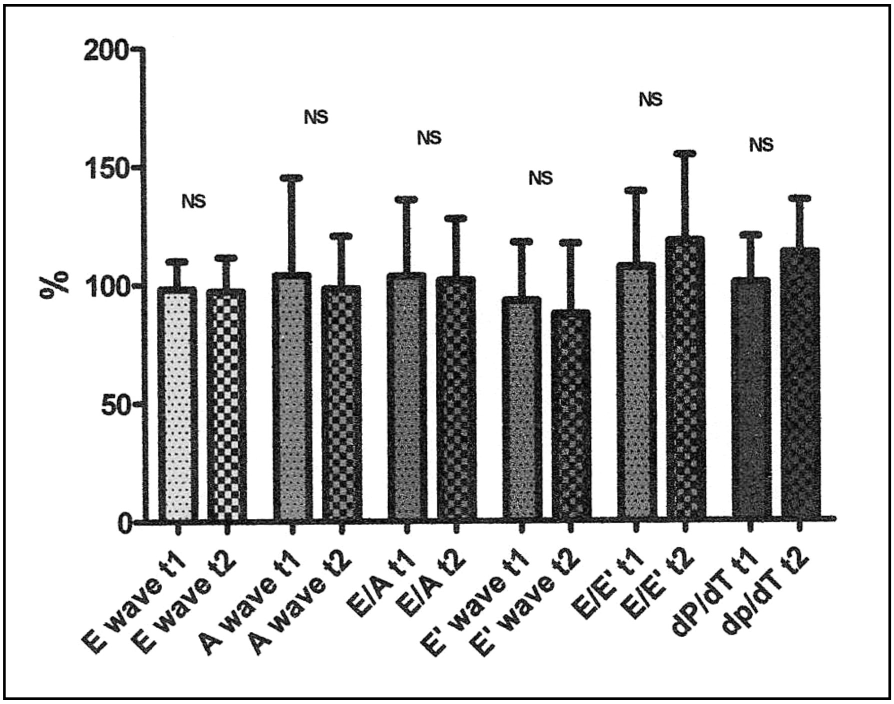

Fig. 1. Parameters measured at the level of the mitral valve at time points T1 and T2. Bars depict mean values ± SD normalized to baseline (T0=100%). (NS= non-significant)

E/E' ratio also reflects high right-side pressures. Hemodynamic parameters were measured and calculated at T1 after 5 minutes of MLD and at T2 at conclusion of MLD. These values were expressed as percentage compared to baseline (100%) as shown in *Table 3*. The results demonstrate that all hemodynamic parameters except for heart rate were not significantly changed during or after MLD with a significant reduction seen in heart rate following MLD (*Tables 2-3; Figs. 1-3*). Following MLD treatment, the circumference of the limbs decreased significantly ($p \leq 0.001$, *Table 3*).

DISCUSSION

In contrast to previously published studies on ISPT (3,4) and MLB (5), which are contraindicated in this setting, MLD does not appear to have any adverse side effects on the hemodynamics of heart failure patients with lower limb edema. One could question if the difference could be related to the different assessment techniques since during ISPT and MLB research, the Swan Ganz catheter technique (invasive technique) was used during the measurements. In our study on MLD, we have used the echo-Doppler technique (non invasive technique). However, Vanoverschelde et al (16) analyzed the relation between Doppler transmitral flow velocity indexes and the pulmonary arterial wedge pressure measurements (PAWP) with catheter and reported a high correlation (0.95) between PAWP and E/A ratio. Moreover, Nagueh et al (6) evaluated the relation of the mitral E/E' ratio to left ventricle filling pressures and found a significant correlation with mean pulmonary capillary wedge pressure with an r value of 0.87 ($p<0.001$). Hadano (17) also confirmed the same observations. Chen et al (18) demonstrated that mitral regurgitation

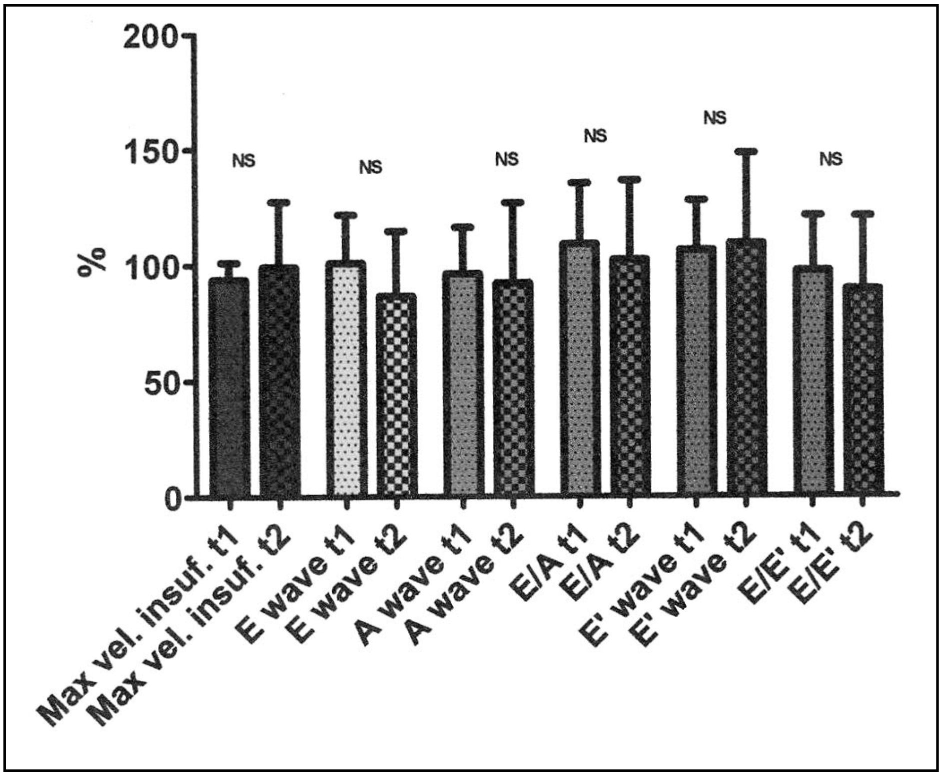

Fig. 2. Parameters measured at the level of the tricuspid valve at time points T1 and T2. Bars depict mean values ± SD normalized to baseline (T0=100%). (NS= non-significant)

velocity spectrum (dP/dt) is a good method to estimate the left ventricular pressure throughout the systole and also that the correlation between Doppler and catheter measurements was similarly good (r = 0.91, p<0.0001). Therefore, according to published literature, the results obtained by echo-Doppler and those obtained by the Swan-Ganz technique may be compared. We conclude that the two evaluation methods are reliable, irrespective of the treatment applied. Accordingly, it is unlikely that the discrepancy between our results and those reported for ISPT and MLB may be attributed to the different treatment techniques.

The pressures applied during MLD are very soft (30 to 40 mm Hg). These pressures do not translocate a large amount of liquid in the venous system. Therefore, they do not produce a large pressure increase in the cardiac cavities. Higher pressures were used in intermittent sequential pneumatic therapy study (3) (80 mm Hg on both legs) and in multilayered bandages study (5) (49.2 mm Hg). Moreover, the ISPT and the MLB were applied on the entire length of the lower limb. In contrast, MLD is applied exclusively at the infiltrated area. Thus, the impact on the displacement of interstitial and intravascular (venous) liquid to the heart is much greater with ISPT and MLB.

Finally, the small number of subjects in this study is related to the difficulty in recruiting and studying patients hospitalized in a coronary unit.

Our results suggest that there is no contraindication to perform MLD in patients with heart failure. When a patient under treatment with MLD for lower limb (lymph)edema develops heart failure, MLD

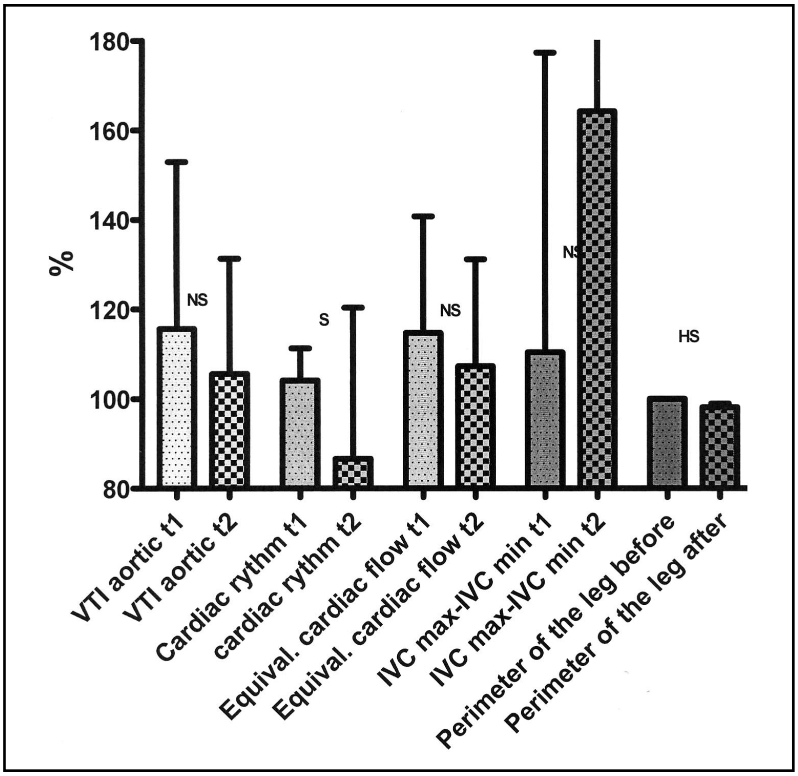

Fig. 3. Hemodynamic parameters measured at T1 and T2. Bars depict mean values ± SD normalized to baseline (T0=100%). (NS= non-significant, S= significant, HS= highly significant)

can be continued as hemodynamic parameters do not seem to be influenced by the treatment.

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