MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.59218/makrjms.2024.2.51.57

Pleural Manometry During Thoracocentesis to Assess Role of Pleural Elastance with Special Reference to Malignant Pleural Effusion

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Key Words
Malignant pleural effusion, CVP manometer, manometry, pleural effusion, pleural elastance and thoracocentesis

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Received: 22 October 2023
Accepted: 1 November 2023
Published: 2 November 2023

Citation: Ritabrata Mitra, Anupam Patra, Swapnendu Misra and Amitabha Sengupta 2024. Pleural Manometry During Thoracocentesis to Assess Role of Pleural Elastance with Special Reference to Malignant Pleural effusion. Res. J. Med. Sci., 18: 51-57, doi: 10.59218/makrjms. 2024.2.51.57

ABSTRACT

Background: Although the importance of pleural physiological measurements remains debated, with doubts supported by the absence of the pleural cavity in some large mammals (e.g.,elephants) and observations that ventilation and pulmonary gas exchange remain intact after pleurodesis, afflictions influencing pleural volume and increasing intrapleural pressure questionably produce symptoms and impact on the lung function of patients with common pleural pathologies like pleural effusion. The measurement of intrapleural pressure and the pattern of changes in relation to volume aspirated in patients with pleural disease may help to optimize diagnosis and guide the therapeutic approach. Clearly, there is lack of adequate data to support routine use of pleural manometry to obtain pleural elastance for diagnostic and therapeutic purpose including dilemma to choose either pleurodesis or indwelling pleural catheter (IPC) to treat malignant pleural effusion for palliation. **Aims and Objectives:** To ascertain whether pleural manometry provides any clue to the aetiology of pleural effusion, to obtain insight into relationship between intrapleural pressure and volume of pleural fluid withdrawn the so-called pleural elastance (PE) curve and its characteristics during therapeutic thoracocentesis, to identify value of pleural elastance in therapeutic decision, especially in case of malignant pleural effusion and to describe the complications of large-volume (>1 Litre) the rapeutic thoracocentes is in relation to pleural elastance. **Patient's and Methods:** The present study was an observational, cross sectional, prospective study conducted from September-August 2021-2022 in the department of Pulmonary Medicine, IPGME and R, Kolkata. Total 90 cases of pleural effusion were included, who underwent pleural manometry using water column manometer designed for central venous pressure (CVP) monitoring during therapeutic thoracocentesis. **Results:** Seventy one patients had normal expandable lung with normal (<14.5 cm of H_2O L^{-1}) pleural elastance curve. Out of rest 19 patients with unexpandable lung, 10 were partially expandable entrapped lung with biphasic pleural elastance curve suggestive of terminally raised PE and 9 were non-expandable trapped lung with monophasic pleural elastance curve suggestive of raised PE. Comparison between transudative and exudative pleural effusion in terms of total amount of fluid aspirated, initial and closing pleural pressure and total pleural elastance done and found statistically not significant. Statistically significant association found neither between pleural elastance and aetiology of pleural effusion (tubercular vs malignant) nor between the pleural elastance among various causes of malignant pleural effusion, nor between the intrapleural pressure change and occurrence of post-aspiration complication. **Conclusion:** Pleural manometry needs to be included during thoracocentesis for better understanding of pleural pathophysiology. However, not all patients are suitable for pleural manometry using CVP manometer due to chance of high respiratory swing caused by uncontrolled cough during therapeutic pleural fluid aspiration. Pattern of pleural elastance can't differentiate transudate from exudate nor predict the aetiology of pleural effusion. Patients having non-expandable trapped lung with raised pleural elastance and partially-expandable entrapped lung with terminally raised pleural elastance can be diagnosed by pleural manometry with pleural elastance curve using CVP manometer in resource-poor setting, who will not benefit from additional pleural fluid removal with subsequent pleurodesis. Large volume ($\geq$1 L) pleural fluid can be removed safely so long pleural pressure does not fall below -20 cm of H_2O.

INTRODUCTION

Pleural manometry (PM) is the direct measurement of pressure in the pleural space through acatheter, that was first performed by the German physician Heinrich Iraenaeus Quincke in *et al.*[1] PM was used to guide collapse therapy in the treatment of active pulmonary tuberculosis toassist to create an artificial pneumothorax before the development of anti-tubercular therapy [2].The use of PM was almost abandoned and relegated to specialized centres for thoracoscopy until Light et al reintroduced interest in 1980s for its use in the management of pleural effusions[3]. Although the actual importance of measuring the pleural physiological parameters remainsdebated, measuring intrapleural pressure and its pattern of changes with respect to volume aspirated in patients having pleural effusion may help to optimize diagnosis and guidance for the therapeutic approach. Clearly, there is lack of adequate data to support routine use of pleural manometry to obtain pleural elastance for diagnostic and therapeutic purpose till date.

As no gold standard intrapleural pressure measurement technique exists with selection predominantly based on operator preference and equipment availability, role of water column manometer to measure the pleural liquid pressure during thoracocentesis in patients with pleural effusion and the value of their measurement in both diagnostic and therapeutic decisions must be explored in resource-poor setting where dedicated commercial digital manometers, manometry systems based on pressure transducers and ICU monitors and complex home-built customized manometers based on hemodynamic electronic transducer are not easily available[4]. As discordance between pleural elastance and post thoracentesis chest radiograph can beconsiderable, additional study evaluating the role of pleural elastance in safe large-volume therapeutic thoracocentesis and in pleurodesis outcomes in malignant pleural effusion associated with trapped or entrapped lung is the need of the hour since we have alternate way for palliation like indwelling pleural catheter (IPC).

MATERIALS AND METHODS

This institution-based prospective observational cross-sectional study evaluated role of pleural manometry using water column manometer designed for central venous pressure (CVP) monitoring (Romsons CVP manometer scale attached to 3-way tap and extension line with its scale reshaped to -18 to +20 cm of H_2O or as appropriate with zero value always set at thoracic puncture level) to measure the pleural liquid pressure during thoracocentesis and the value of their measurement of pleural elastance in both diagnostic and therapeutic decisions in patients with pleural effusion including malignant pleural effusion.

Pleural pressure recording was done during thoracentesis by connecting the aspiration catheter and attached syringe to CVP manometer in our low-resource settings, where pleural manometry itself was performed to avoid additional recurring costs of further investigations and procedures. We performed pleural manometry in our indoor clinical settings with (1) 16 G IV cannula catheter, (2) two 3-way stopcock adapters, (3) two extension lines, (4) 50 mL syringe, (5) CVP manometer and (6) a drainage collection bottle. The patient was sitting with his arms on the back of the chair, causing the intercostal spaces to be extended and facilitates access. The most dependent portion of the pleural effusion was identified clinically and radiologically by ultra sound. After local infiltration of puncture site with 2% lignocaine aseptically the IV cannula was advanced till fluid got aspirated at upper border of the lower rib of relevant intercostals space. Then the needle was withdrawn and the catheter fixed through two 3-way adapters fixed in series placed in between as shown in Fig. 1.

The side ports of the 3-way adapters were connected to the extension lines with one draining into the drainage collection bottle and the other, pre-flushed with normal saline, to CVP manometer. The stopcocks of the adapters were rotated such that fluid was initially aspirated and drained into the drainage bottle. At fixed intervals (as per protocol mentioned in data collection and outcome definition section later) the stopcocks were rotated such that the manometer was in series with the aspiration catheter whereas the syringe as well as the draining infusion line were no longer in continuity. The pressure recording was taken when the meniscus steadied between two values consistently (for minimum five seconds) following which the lower value was recorded at end-expiration. The system (IV tubing/extension line) was purged of air with normal saline and zero value on CVP manometer, with its scale reshaped according to clinical setup, was always set at the thoracic puncture level as already mentioned.

Initial pleural pressure (end-expiratory pleural pressure values after the withdrawal of initial 10 mL of pleural fluid) interim pleural pressure (end-expiratory pleural pressure after the removal of every 500 mL for the first litre, then after the withdrawal of every 250 mL for the second litre and every 100 mL there after until the procedure terminated), closing pleural pressure (end-expiratory pleural pressure recorded at termination of thoracocentesis based on when no more pleural fluid could be obtained or the patient developed symptoms like chest pain, cough or chest tightness related to the removal of fluid and pleural pressure becomes -20 cm of H_2O or lower) and pleural elastance (change observed in pleural pressure divided by the amount of fluid removed) curves were obtained.

Inclusion criteria:

- Patients of pleural effusion diagnosed clinic-radiologically
- Age 18 years or above, either sex
- Needs therapeutic thoracocentesis

Exclusion criteria:

- Lack of informed consent
- Age <18 years
- Health status too poor to sit for pleural manometry
- Uncontrolled cough during pleural fluid aspiration
- Loculated pleural effusion
- Empyema thoracis
- Bronchopleural fistula

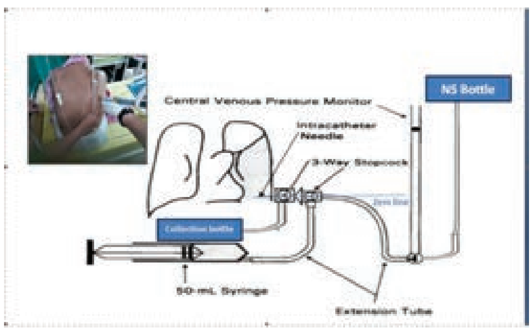

Fig. 1: Schematic diagram (modified from reference 24) of pleural manometry using CVP manometer (Real life scenario inset)

RESULTS

Total 90 cases with pleural effusion were included and completed pleural manometry in this study. It is needed to be mentioned that exclusion of 33 patients (13 TPE, 16 MPE, 1 CHF, 2 SLE and 1 RA) took place due to uncontrolled cough during therapeutic pleural fluid aspiration rendering pleural manometry not possible during therapeutic thoracocentesis. Out of 90 patients finally included and subjected to pleural manometry in this study, 71 patients had normal expandable lung with normal (<14.5 cm of H_2O L^{-1}) pleural elastance. Out of rest 19 patients with un-expandable lung, 10 were partially expandable entrapped lung and 9 were non-expandable trapped Lung (Fig. 2). Mean total

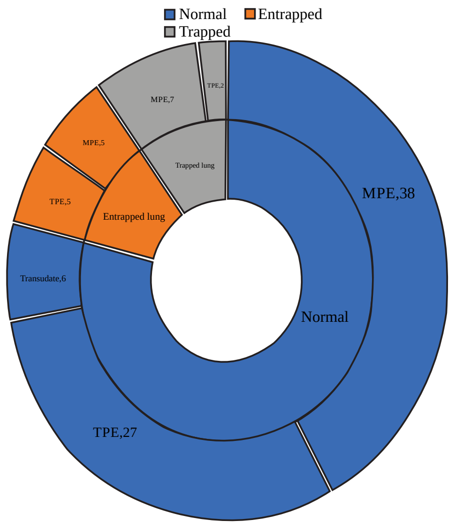

Fig 2: Distribution of pleural elastance according to aetiology of pleural effusion Among 9 trapped lung, Tuberculous pleural effusion (TPE) 22%, Malignant pleural effusion (MPE) 78%. Among 10 entrapped lungs, both TPE and MPE constituted 50% each. For 71 normal elastance cases, 38% were TPE (all exudative) 53% were MPE (all exudative) and rest 9% transudative effusion (4 cases of hepatic hydrothorax and 2 cases of Congestive cardiac failure) to the 50 mL syringe

Table 1: Comparison of subgroups by PE pattern (normal entrapped trapped) One-way analysis of variance

	SS-effect	DF-effect	MS -effect	SS-error	DF-error	MS-error	F	p-value
Age	327.1	2	163.6	18667	87	214.56	0.76	0.470
DurnIll-m	2.2	2	1.1	223	87	2.56	0.43	0.651
PF-Protein	0.4	2	0.2	53	87	0.61	0.35	0.708
PF-LDH	351448.2	2	175724.1	3872422	87	44510.59	3.95	0.023
PF-ADA	995.4	2	497.7	26946	87	309.72	1.61	0.206
PPL-Init-cm H_2O	1563.8	2	781.9	3989	87	45.85	17.05	0.000
PPL-0.5-1	2253.4	2	1126.7	3579	87	41.14	27.39	0.000
PPL-0.5-2	2696.2	2	1348.1	3572	85	42.03	32.08	0.000
PPL-0.25-1	1819.8	2	909.9	3684	77	47.84	19.02	0.000
PPL-0.25-2	57.7	1	57.7	3723	64	58.17	0.99	0.323
PPL-0.25-3	669.3	1	669.3	3264	45	72.52	9.23	0.004
PPL-0.25-4	36.7	1	36.7	2730	26	104.98	0.35	0.560
PPL-0.1-1	0.7	1	0.7	1300	16	81.26	0.01	0.929
PPL-0.1-2	54.1	1	54.1	780	10	78.03	0.69	0.424
PPL clo	3137.3	2	1568.7	8448	87	97.10	16.15	0.000
Fluid removed	7.0	2	3.5	12	87	0.14	25.93	0.000

Table 2: Comparison of sub-groups by PE pattern (normal entrapped trapped)

Kruskal wallis ANOVA by ranks, kruskal wallis test: H (2, N = 84) =.3945041 p = 0.821	Kruskal wallis ANOVA by ranks. mMRC kruskal wallis Mmrc test: H (2, N = 84) =.3945041 p = 0.821		
	Code	Valid-N	Sum of ranks
Normal	101	65	2813
Entrapped	102	10	388
Trapped	103	9	369
Kruskal wallis ANOVA by ranks, PE total (kruskal wallis test: H (2, N = 84) =37.58859 p = < 0.001			
Normal	101	65	2198.000
Entrapped	102	10	665.000
Trapped	103	9	707.000

Table 3: Comparison between tuberculous and malignant pleural effusion: student's independent samples t-test

	Mean tub	Mean malig	t-value	df	p-value	Valid N tub	Valid N	Std.dev. malig tub	Std.dev. malig
Age	43.79	54.96	-3.573	82	0.001	34	50	16.549	12.100
DurnIll-m	1.18	3.77	-11.18	82	0.000	34	50	0.598	1.250
mMRC	2.12	3.02	-6.655	82	0.000	34	50	0.686	0.553
PF=Protein	4.32	4.19	0.847	82	0.399	34	50	0.926	0.464
PF-LDH	734.65	918.98	-5.175	82	0.000	34	50	219.068	103.232
PF-ADA	45.82	25.96	6.069	82	0.000	34	50	15.635	14.073
PPL-Init-cmH2O	14.54	12.07	1.407	82	0.163	34	50	8.421	7.544
PPL-0.5-1	11.57	9.37	1.216	82	0.227	34	50	8.485	7.920
PPL-0.5-2	9.65	7.28	1.233	80	0.221	33	49	8.125	8.830
PPL-0.25-1	7.72	5.74	0.982	72	0.329	30	44	7.682	9.018
PPL-0.25-2	3.37	5.03	-0.835	60	0.407	26	36	8.371	7.241
PPL-0.25-3	-0.34	1.04	-0.473	41	0.639	19	24	10.115	9.040
PPL-0.25-4	-3.45	-3.81	0.089	25	0.930	11	16	10.996	9.854
PPL-0.1-1	-6.90	-7.92	0.216	16	0.832	5	13	9.423	8.860
PPL-0.1-2	-14.83	-12.39	-0.405	10	0.694	3	9	5.838	9.701
PPL-clo	0.53	-0.73	0.485	82	0.629	34	50	11.222	11.997
Fluid removed	1.56	1.58	-0.211	82	0.833	34	50	0.461	0.477
PE Total	9.79	8.40	1.061	82	0.292	34	50	7.518	4.512

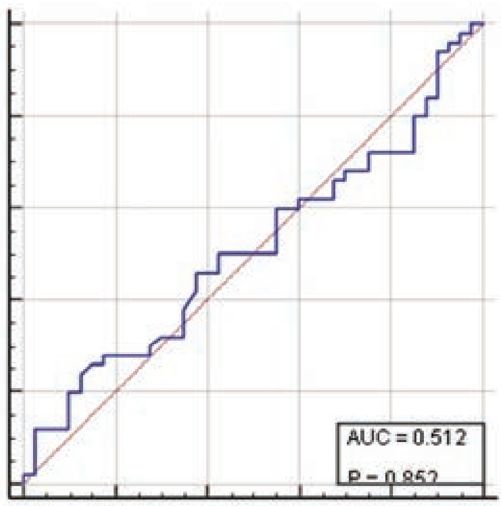

Fig. 3: ROC curve analysis to identify cut-off value of PE Total that can indicate malignant pleural effusion

pleural elastance (±SD) was 6.66±2.61, 12.83±3.41 and 20.07±9.92 cm of H_2O L^{-1} for normal, entrapped and trapped lung respectively.

No statistically significant association found between pleural elastance and aetiology of pleural effusion (pvalue 0.379 using Mann Whitney test for TPE vs MPE). Again, no statistically significant difference wasfound between the pleural elastance among various causes of malignant pleural effusion. Because of the limited number of cases of individual malignancy, attempt was not made for any subgroup comparison by type of malignancy causing pleural effusion (Table 4-9). Mean pleural fluid volume aspirated was 1.56±0.45 L (mean±SD) with mean pleural fluid volume aspirated as 1.62±0.38 L for normal lung, 1.9±0.21 L for entrapped lung and 0.77±0.33 L for trapped lung (Table 1-3). Regarding causes of pleural tap termination, pleural tap was terminated as pleural pressure dropped to -20 cm of H_2O or even less for 9 cases (6 MPE and 3 TPE), pleural tap was terminated as chest pain appeared in 49 cases (29 MPE, 17 TPE and 3 transudative effusion); tap pleural was terminated as cough developed in 25 cases 13 9 TPE and 3 transudative effusion) and pleural tap was terminated as no more pleural fluid was aspirated for7 cases (2 MPE and 5 TPE).

Correlation between the amount of pleural fluid removed and initial pleural pressure shows poor correlation and statistically not significant (r = 0.160 and p-value = 0.132). Correlation between the amount of pleural fluid removed and closing pleural pressure shows poor inverse correlation but statistically significant (r = -0.287 and p = 0.006). Correlation between amount of fluid removed and total pleural elastance shows poor inverse correlation but statistically significant (r = -0.236 and p=0.025) (Table 1 and 3) In tubercular and malignant pleural effusion cases, statistically significant difference was observed with respect to age, duration of illness and pleural fluid ADA and LDH level but there was no statistically significant difference was observed with respect to pleural fluid protein level as well as volume of pleural fluid aspirated. Comparison between transudative (due to CCF and HH) and exudative (TPE and MPE) pleural effusion in our study in terms of total amount of fluid aspirated, initial and closing pleural pressure and total pleural elastance done and found statistically not significant. Further, comparisonbetween malignant and tubercular pleural effusion in terms of initial and closing pleural pressure and total pleural elastanceand

Table 4: Correlation between initial pleural pressure and volume of pleural fluid removed

Variable Y	PPL-Init-cmH_2O
Variable X	Fluid removed
Sample size	90
Correlation coefficient pearson's	0.160
Significance level	p = 0.132
95% Confidence interval for	-0.049-0.356

Table 5: Correlation between closing pleural pressure and volume of pleural fluid removed

Variable Y	PPL-clo
Variable X	Fluid removed
Sample size	90
Correlation coefficient pearson's	-0.287
Significance level	p = 0.006
95% Confidence interval for	-0.466-.085

Table 6:Correlation between total pleural elastance and volume of pleural fluid removed

Variable Y	PE Total
Variable X	Fluid removed
Sample size	90
Correlation coefficient pearson's	-0.236
Significance level	p = 0.025
95% Confidence interval for	-0.422-0.029

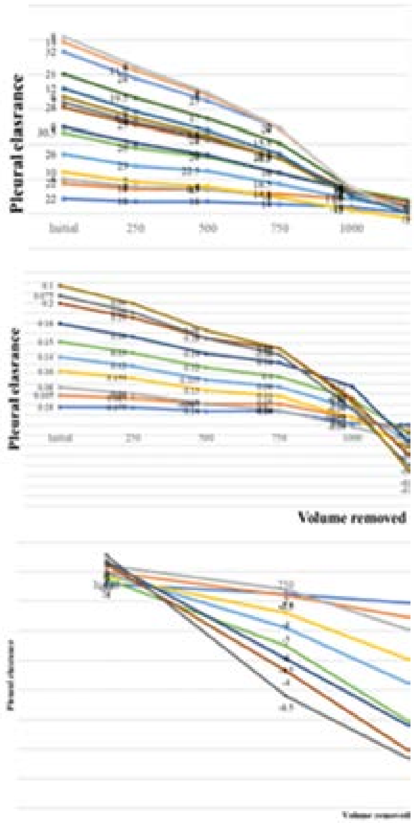

Fig. 4: Pleural elastance curves, X axis – volume of pleural fluid removed (in L), Y axis – intrapleural pressure measured by CVP manometer (in cm of H2O)If distribution of pleural elastance is considered according to aetiology

found statistically not significant. If distribution of pleural elastance is considered according to aetiology, there are 9 trapped lung among which TPE 2 (22%) and MPE 7 (78%) among 10 entrapped lungs, TPE 5 (50%) and MPE 5 (50%) and for 71 normal elastance cases, TPE 27 (38%) MPE 38 (53%) and transudative effusion 6 (9%). Pleural elastance curves are shown in Fig. 4. 71 patients had normal expandable lung with normal (<14.5 cm of H_2O L^{-1}) pleural elastance curve. Out of rest 19 patients with unexpandable lung, 10 were partially expandable entrapped lung with biphasic pleural elastance curve suggestive of terminally raised PE and 9 were non-expandable trapped lung with monophasic pleural elastance curve suggestive of raised PE. Post-aspiration complication observed in 21 cases with pneumothorax in 3 cases (all MPE), chest discomfort in 18 cases (9 TPE and 9 MPE) and no re-expansion pulmonary Oedema noted. From analysis of values of area under receptor operating characteristic curve (ROC AUC 0.512), standard error (SE 0.061 with 95% confidence interval 0.404-0.618), sensitivity and specificity, it is imperative that there is no reliable cut-off value of pleural elastance that can indicate malignant pleural effusion (Fig. 3).

DISCUSSIONS

The monitoring of pleural pressure (Ppl) during thoracocentesis not only provides a better understanding ofthe real-time physiology of the pleural space but also helps to prevent pressure-related complications such as re-expansion pulmonary oedema[4,5]. In 1980, Light and colleagues measured pleural elastance (PE) in 52 patients with pleural effusion using U-tube manometer during thoracocentesis and described the following three distinct pleural elastance curves (i) removal of a large amounts of fluid with minimal change in pressure (normal pleural elastance, as can beseen in patients with hepatic hydrothorax orcongestive heart failure) (ii) a relatively normal initial curvefollowed by a sharp drop in pressure-called entrapped lung or lung entrapment and (iii) a negative initial pressure with a rapid drop in pressure, called trapped lung. The initial pleural pressure ranged from +8 to -21 cm H_20. The rate of pleural pressure change as fluid was withdrawn was highly variable. In 13 of 52 procedures (25%) thoracentesis was terminated because the pressure fell below -20 cm H_20. The authors concluded that because large changes in pleural pressures are not readily detectable by the operator, pleural pressures should be monitored when large amounts (>1,000 mL) of pleural fluid are removed to increase the safety of the procedure. In 1997, Lan and colleagues measured pleural elastance using U-tube manometer in 65 patients with malignant pleural effusion[5]. Patients with an elastance of 19 cm H_2O or more had a higher incidence of trapped lung (11 of 14 patients) than did those with an elastance less than[5] 19 cm H_20 (3 of 51 patients). None of the 14 patients with an elastance of 19 cm H_20 or more and none of the 14 patients witha trapped lung had successful pleurodesis. 42 of 43 patients with an elastance less than 19 cm H_20 who did not have a trapped lung had successful pleurodesis. They, therefore, concluded that pleural elastance seemed tobe the best predictor for trapped lung and outcome of pleurodesis, although outcome was also correlated with pH and glucose levels of the effusion.

In 2000, Villena *et al* .measured pleural elastance in 61 patients using water column manometer designed formonitoring central venous pressure[4], with its scale reshaped to a -25 to +10 cm H_2O range and value zero was set at the thoracic puncture level where manometer was attached to the needle with a connecting catheter filled with saline. The value of pleural pressure taken was the mean of the inspiratory and expiratory values that was measured before removing any fluid, after the removal of every 500 mL for the first litre, then after the withdrawal of every 200 mL for the second litre and every 100 mL thereafter until theprocedure was completed whenno more fluid could be obtained the patient developed symptomsrelated to the removal of fluid (i.e., chest pain, cough or chest tightness) or pleural pressure became-20 cm H_2O or lower. Only the four patients with suspected trapped lung had an initial pleural pressure lower than 24 cm H_2O and a PE higher than 33 cm H_2O L^{-1}. There was a weak correlation (r 50.52) between PE during the first 0.5 L aspiratedand the total amount of fluid aspirated. Partial PE values were 10, 7.5 and 14 cm H_2O L^{-1} at the early, intermediate and late phases of therapeutic thoracentesis respectively. No complications were found except for nine pneumothoraxes. They concluded that the technique wasclinically helpful because large amounts of pleural fluid could be aspirated with few and mildcomplications as well as it allowed clinicians to support the preliminary diagnosis of trapped lung. In our present study, we also used CVP manometer for pleural manometry in 90 cases which included 6 transudative pleural effusions (2 due to congestive cardiac failure and 4 due tohepatic hydrothorax) and 84 exudative pleural effusions out of which 50 cases were due tomalignancy (MPE) and 34 due to tuberculosis (TPE). Among cases of MPE 18 trapped, due to adenocarcinoma lung, 11 due to squamous cell carcinoma lung, 9 dueto small cell carcinoma lung, 10 due to non-Hodgkin lymphoma and one each due to pleural metastasisfrom carcinoma ovary and breast. In TPE and MPE cases, statistically significant difference wasobserved with respect to age, duration of illness and pleural fluid ADA and LDH level, butthere was nostatistically significant difference was observed with respect to pleural fluid protein level, pleural elastance and initial and closing pleural pressure as well as volume of pleural fluid aspirated.

It was found that distribution of pleural elastance according to aetiology comprised of 9 trapped lungsamong which TPE 2 (22%) and MPE 7 (78%) 10 entrapped lungs among which TPE 5 (50%) and MPE 5 (50%) and 71 fully expandable lung with normal pleural elastance among which TPE 2 7 (38%) MPE 38 (53%) and transudative effusion due to congestive cardiac failure (CCF) and hepatic hydrothorax (HH) 6 (9%). However, from values of area under ROC curve, sensitivity and specificity, it was apparent that there was no reliable cut off value of pleural elastance that can indicate malignant pleural effusion. Correlation between the amount of pleural fluid removed and initial pleural pressure was found as poor correlation and statistically not significant (r = 0.160 and p-value = 0.123) correlation between the amount of pleural fluid removed and closing pleural pressure was found as poor inverse correlation but statistically significant (r = 0.287 and p-value = 0.006) and correlation between amount of fluid removed and total pleural elastance found as poor inverse correlation but statistically significant (r = 0.236 and p-value = 0.025). Comparison between transudative and exudative pleural effusion interms of total amount of fluid aspirated, initial and closing pleural pressure and total pleural elastance done and found statistically not significant. Comparisonbetween malignant andtubercular pleural effusion in terms of total amount of fluid aspirated, initial and closing pleuralpressure and total pleural elastance and found statistically not significant. No statistically significant association found between pleural elastance and aetiology of pleural effusion (TPE vs MPE) (p-value 0.379 using Mann Whitney test). Again, no statistically significant difference was found between the pleural elastance among various causes of malignant pleural effusion.

Post-aspiration complication observed in 21 cases with 3 cases of pneumothorax (all MPE) no re-expansion pulmonary oedema was found and chest discomfort appeared in 18 cases (9TPE and 9 MPE) thatpersisted for more than 2 hours but resolved subsequently without anydefinite medical intervention. Cause of pleural tap termination was either pleural pressuredrops to 20 cm of H_2O or less (6 MPE and 3 TPE) or transient chest pain (29 MPE, 17 TPE and 3 transudative effusion) or no pleural fluid aspirated in rest of the cases. Comparison between post-aspiration complication and no-complication group in terms of total amount offluid aspirated, initial and closing pleural pressure and total pleural elastance and found statistically not significant for total amount of fluid aspirated.

Pleural pressure is likely to be positive initially inmassive malignant pleural effusion and is expected todecrease during aspiration. But ifpleural pressure falls below -19 cm of water, it is suggestive of unexpandable lung for which fibreoptic bronchoscopy is justified to exclude any endobronchial lesion.Pleural pressure guided therapeutic thoracentesis can enable large volume of pleural fluid to beremoved to make ultrasound guided biopsy easier to be performed.

In study by Feller-Kopman et al. who investigated the relationship of patients' symptoms during therapeutic thoracocentesis to pleural pressure (Ppl) the closing pressures were significantly lower in the group ofpatients who experienced chest discomfort compared to patients who were asymptomatic[6]. They also found that only 22% of patients in whom chest discomfort developed and 8.6% of patients in whomsymptoms did not develop, had potentially dangerous Ppl values (i.e., lower than -20 cm H_2O). At thispoint we may conclude that development of symptoms alone is not an indication to terminate the procedureand pleural pressure measurement at this time would be of great value to take the decision of termination.

Chopra *et al*. studied 70 patients with MPE who underwent therapeutic pleural drainage guided by pleural manometry and found elevated pleural elastance as well as incomplete lung expansion in 36 of 70 (51.4%) and 38 of 70 (54%) patients, respectively[7]. Patients with normal pleural elastance had an OR of 6.3 ofhaving complete lung expansion compared with those with elevated pleural elastance (p = 0 .0006). However, 20 of 70 (29%) patients exhibited discordance between post-procedural chest radiographic findings and the pleural manometry results in their study. Among patients who achieved complete lung expansion on the post-drainage chest radiograph, 9 of 32 (28%) had elevated pleural elastance. In addition, pleural elastance was normal in 11 of 38 (34%) patients who had incomplete lung expansion as detected according to the post-thoracentesis chest radiograph. The authors speculated that the post thoracentesis CXR may show incomplete lung expansion while the pleural elastance is normal because either the drainage was prematurely stopped due to a mechanism other than unexpandable lung, such as the presence of pleural adhesions not allowing complete drainage or chest pain due to the catheter irritating the diaphragm the pleural elastance may be falsely normal in cases of drainage-related pneumothorax that may be the result of air entry from the lung into the pleural space from the development of a pressure-dependent alveolar-pleural fistula[8]. They concluded that pleural manometry may have a role in addition to the post thoracentesis CXR in selecting patients for pleurodesis that needs further studies to look for pleurodesis outcome. Therefore, performing pleural manometry has not conclusively been shown to have an effect on better patient outcomes.

Based on discussion above, it is clear that although pattern of pleural elastance can't differentiate transudate from exudate nor predict the aetiology of pleural effusion, it can help to detect non expendable trapped and entrapped lung by pleural manometry using CVP manometer in resource-poorsetting, who will not benefit from additional pleural fluid removal with subsequent pleurodesis[9,10].

CONCLUSION

Pleural manometry needs to be included during thoracocentesis for better understanding of pleural pathophysiology. However, not all patients are suitable for pleural manometry using CVP manometer due tochance of high respiratory swing caused by uncontrolled cough during therapeutic pleural fluid aspiration.Use of handheld digital manometer can overcome this problem. Pattern of pleural elastance can't differentiate transudate from exudate nor predict the aetiology of pleural effusion. Patients having non-expandable trapped lung with raised pleural elastance and partially-expandable entrapped lung with terminally raised pleural elastance can be diagnosed by pleural manometry with pleural elastance curve using CVP manometer in resource-poor setting, who will not benefit from additional pleural fluid removal with subsequent pleurodesis. Large volume (>1 L) pleural fluid can be removed safely so long pleural pressure does not fall below -20 cm of H_2O.

REFERENCES

1. Feller-Kopman, D., 2007. Therapeutic thoracentesis: The role of ultrasound and pleural manometry. Curr. Opin. Pulm. Med., 13: 312-318.
2. Jacobs, S., 1937. Manometry in the conduct of artificial pneumothorax. Dis. Chest., 3: 18-20.
3. Light, R.W., S.G. Jenkinson, V.D. Minh and R.B. George, 1980. Observations on pleural fluid pressures as fluid is withdrawn during thoracentesis. Am. Rev. Respir. Dis., 121: 799-804.
4. Villena, V., A. López-Encuentra, F. Pozo, A. De-Pablo and P. Martín-Escribano, 2000. Measurement of pleural pressure during therapeutic thoracentesis. Am. J. Respir. Crit. Care Med., 162: 1534-1538.
5. Lan, R.S., 1997. Elastance of the pleural space: A predictor for the outcome of pleurodesis in patients with malignant pleural effusion. Ann. Internal Med., 126: 768-774.
6. Feller-Kopman, D., A. Walkey, D. Berkowitz and A. Ernst, 2006. The relationship of pleural pressure to symptom development during therapeutic thoracentesis. Chest., 129: 1556-1560.
7. Chopra, A., M.A. Judson, P. Doelken, F. Maldonado N.M. Rahman, J.T. Huggins, 2020. The relationship of pleural manometry with postthoracentesis chest radiographic findings in malignant pleural effusion. Chest, 157: 421-426.
8. Mentzer, S.J., A. Tsuda and S.H. Loring, 2018. Pleural mechanics and the pathophysiology of air leaks. J. Thoracic. Cardiovasc. Surg., 155: 2182-2189.
9. Ayub, I., 2019. Approach to malignant pleural effusions: Role of pleural manometry exemplified by case scenarios. Lung. India., 36: 142-148.
10. Lester, M., F. Maldonado, O.B. Rickman, L.J. Roller, S.K. Avasarala, J.M. Katsis and R.J. Lentz, 2022. Association between terminal pleural elastance and radiographic lung re-expansion after therapeutic thoracentesis in patients with symptomatic pleural effusion: A post-hoc analysis of a randomised trial. BMJ. Open., Vol. 12. 10.1136/bmjopen-2021-053606.