ORIGINAL RESEARCH PAPER

Cardiology

ULTRASOUND LUNG COMETS AND THEIR UTILITY IN PREDICTING LEFT VENTRICULAR FILING PRESSURES

KEY WORDS:

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1. Introduction:

The generally held notion, until recently was that ultrasound imaging of the lung parenchyma is not useful because the air content in the pulmonary parenchyma rapidly dissipates the ultrasound energy before it produces any useful images.[1] In pulmonary edema Ultrasound waves get a medium to propagate (fluid in the lungs) and produce images which can even help us semi-quantitate the degree of pulmonary congestion.[2] Ultrasound lung comets are artefacts produced when there is a marked difference in acoustic impedance between a sound conducting object and its surroundings. This study was conducted with the aim of determining whether ULC can be a rapid, accurate and easily available diagnostic tool for non-invasive bedside assessment of LV filling pressures and pulmonary congestion in the emergency setting.

2. Materials and methods:

This prospective observational study was conducted at the department of cardiology, Rajiv Gandhi Government General Hospital, Chennai. Forty six consecutive patients who were admitted to the Coronary Care unit with ST Elevation Myocardial Infarction (STEMI) and Killip Class of II-IV, were included in the study. STEMI patients with Killip Class I, Conditions which were likely to affect the identification of Ultrasound Lung Comets e.g. Patients on Mechanical Ventilation, Pneumothorax, known active infective lung pathology (Pulmonary tuberculosis, Pneumonia, Lung access) were excluded. Similarly patients with Renal disease, Liver disease and other volume overload states which are known to affect the LV filling pressures were excluded. Those patients who did not consent for the study and those who were unable to give consent were also excluded.

2.1 Recording the Lung comets:

All patients included in the study were subjected to comprehensive Trans-thoracic 2D Echocardiogram, using Esoate My Lab Gold 30 echocardiography machine. Using the same cardiac probe, lung fields were studied with the patients in supine position from Parasternal to Mid-Axillary line in the 2nd to 5th intercostal space on the right and 2nd to 4th intercostal space on the left.[3] The ULC score was calculated by summing the number of comet artefacts in each of the examining sites.[3] (figure-1)ULC image was defined as a hyperechogenic, coherent vertical bundle with narrow base, spreading from the transducer to the opposite border of the screen.[4]

2.2 Echocardiography to estimate the LV filling pressures

LV filling pressures were estimated using the equation PCWP = 1.24*[E/e'] + 1.9 validated in the study by Nagueh et al.[5] Doppler interrogation of Mitral valve inflow velocities was done and E wave amplitude, A wave and deceleration time (DT) were measured. Tissue Doppler TD interrogation of myocardial velocities were done both in the septal and lateral position. The lateral e'is used to calculate the LV filling pressure using the above equation. The septal Tissue Doppler velocities were used when velocities recorded in the lateral position were affected by regional wall motion abnormalities or when there were technical difficulties in recording the lateral TD velocities. The mean of three readings were taken in all possible measurements. Left ventricular ejection fraction and Regional wall motion abnormalities were also evaluated in all patients.

2.3 Statistical analysis

Statistical analysis was done using the computer software IBM SPSS version 22. The continuous variables are presented as Mean ± SD (Standard Deviation). Categorical data are presented as % (percentage) of total. Correlations between continuous data were determined using the linear regression model and Pearson's correlation coefficient was computed. The analysis which had p values <0.05 were considered statistically significant.

3. Results

The baseline clinical profile of all the patients are summarised in table 1. The study sample of forty six patients included males and females. The mean age was 54 years with SD of 8.6. 37 patients were male while 9 were female. 33 patients had an anterior wall Myocardial infarction whereas 13 had inferior wall Myocardial infarction. The mean Ejection fraction was 43% ± 7%. The mean Doppler derived PCWP was 16 ± 8.7 mmHg. The ULC score showed significant correlation with Doppler derived PCWP values (Pearson's two tailed r = 0.77 & p<0.001). Similarly there was significant inverse correlation of ULC score with Ejection fraction (Pearson's two tailed r = -0.76 & p<0.001).

4. Discussion

The comet tail sign in ultrasonography was first described in1982, by Zisskin et al, in a patient with abdominal short gun wound. Each lead pellet in the short gun wound acted as a source for the reverberation artefact, producing a trail of dense continuous echoes, simulating a comet tail.[6] These comet tail signs were frequently seen in patients having pulmonary edema and based on this Lichtenstein et al in 1997 described the 'comet tail artefact'and its association with alveolar-interstitial syndrome.[7] However the utility of 'comet tail artefact'or more aptly known as the 'Ultrasound lung comets'in cardiology practice was not realised until in 2004, when Jambrik et al, described the correlation between extravascular lung water assessed by chest x-ray and the number of comets detected in the chest by echocardiography. [8]

4.1 Physics behind the formation of Ultrasound lung comets

In all diagnostic B-mode ultrasound scans, the images are produced when ultrasound beam is reflected off an interface between two substances with different acoustic impedance. In normally aerated lung there is no interface for ultrasound beam to get reflected and produce meaningful image and also due to high impedance of air in the lungs, the ultrasound beam gets rapidly attenuated. However in the presence of pulmonary congestion the interlobular septa gets filled with water and there is an air-water interface for the ultrasound beam to get reflected back and to produce images. The fluid filled interlobular septa, which has low acousticimpedance is surrounded by air in the lungs, which has high impedance, causing the reflected ultrasound beam to reverberate. The time lag between successive reverberation is interpreted by the ultrasound machine as distance, generating a series of closely spaced pseudo-interfaces (lines) seen as the comet tail artefact (figure-2).[3]

4.2 Types and sources of Ultrasound lung comets

There are two types of ULCs (i) Cardiogenic and (ii)Pneumgenic. Cardiogenic ULCs are produced when the interlobular septa are filled with water due to pulmonary congestion due to raised left sided filling pressures. These are analogous to the Kerley B lines seen in Chest radiograms. The Pneumogenic ULCs are seen when the interlobular septa gets thickened due to fibrosis as in ILD, COPD, etc.[3] The two types of ULCs can be differentiated by the fact that cardiogenic ULCs are numerous, closely spaced and more common in the right side and disappear with diuretic or other heart failure therapy. The pneumogenic ULCs are fixed and more sparsely located.

4.3 ULCs utility in quantifying extravascular lung water

Heart failure patients have increased PCWP (hemodynamic congestion) resulting in extravasation of fluid into the lung interstitium due tohigh pulmonary capillary hydrostatic pressures which disturb Starling's equilibrium, withoutdisruption of the capillary integrity.[9,10] This is then followed by alveolar edema and at this stage it becomes clinically recognisable (clinical congestion). The radiological signs appear much later (radiological congestion). [11] ULCs are able to detect increased PCWP even before it becomes clinically recognisable.[11] This is because alveolar edema is always preceded by interstitial edema, the diagnosis of which at the bedside is difficult. ULCs are of great utility in detecting pulmonary edema at such an early stage. Detection and treatment of pulmonary congestion before it is clinically evident may prevent hospitalization and progression of heart failure.Agricolaet al have shown that the ULC score has excellent accuracy in quantifying LV filling pressures.[12,13]

4.4 ULCs advantage over conventional methods of assessing pulmonary congestion

Identifying and quantifying ULCs has many advantages over conventional methods of assessing pulmonary congestion. Though invasive methods like direct measurement of PCWP using Swan-ganz catheter is accurate, it's not feasible in all cases and has inherent risk of complications due to its invasive nature. However non-invasive assessment of PCWP using ULCs can be done at the bedside, even with a simple hand-held portable echocardiographic device[14]. ULCs are very easy to assess and interpret with a very short learning curve.[14] The inter and intra operator variability is very less.[4] Unlike Chest radiogram there are no concerns regarding ionizing radiation and it is not dependent on cardiac acoustic window or patient decubitus. It is useful in serial monitoring of therapy as changes can be instantaneously noted flowing therapy unlike chest radiogram, which has a time lag.[15,16]Furthermore cardiac function and pulmonary congestion can be assessed in the same sitting using the same device, saving valuable time, which may appeal to the Emergency care physicians.

5. Limitations

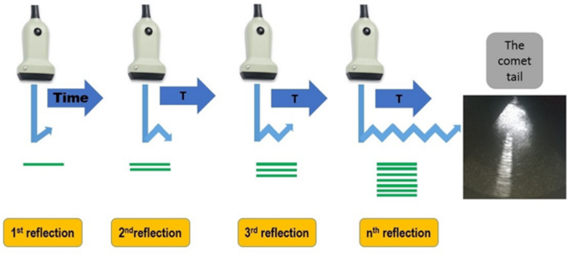
Our study is a single center study with a small sample size. The Left ventricular filling pressures were not invasively measured, we only used non-invasive Doppler estimates of PCWP for our study. Further we included only patients with STEMI in our study and most of them would be having acute elevation of LV filling pressures, hence we cannot generalise the results to other chronic heart failure patients, with chronically elevated LV filling pressures.

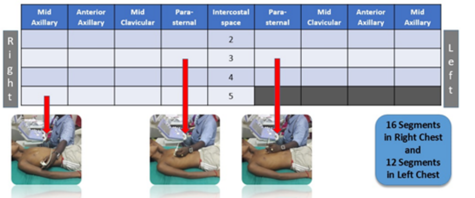
6. Conclusions

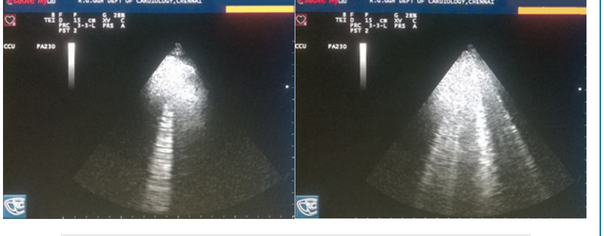
Ultrasound Lung comets have the potential to become an indispensable tool for the rapid identification of cardiogenic pulmonary edema and elevated left ventricular filling pressures in patients presenting with dyspnea to the emergency department.

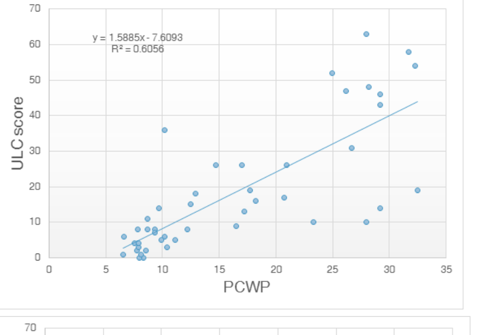
7. Conflict of interests

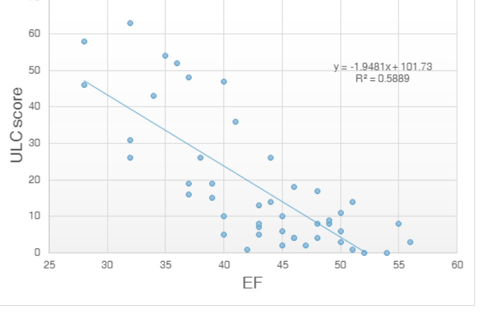
The authors have none to declare.











Clinical and Echocardiographic characteristics of study Patients	
Age	54.1±8.6 years
Sex	Male - 37; Female - 9
Diabetes Mellitus	Yes – 22%; No – 78%
Hypertension	Yes – 30%; No – 70%
Smoking	Yes – 43%; No – 57%
Alcohol	Yes – 26%; No – 74%

Volume-7 | Issue-6 | June-2018 | PRINT ISSN No 2250-1991

AWMI/IWMI	AWMI –72%; IWMI – 28%
Killip Class	II –76%; III – 17%; IV – 7%
Ejection Fraction	43±6.9 %
Mitral inflow - E	0.68±0.20 m/s
Mitral inflow - A	0.57±0.17 m/s
e' (lateral)	0.08±0.03 m/s
PCWP (Doppler derived)	16±8.7 mmHg
ULC score	18±17.7

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